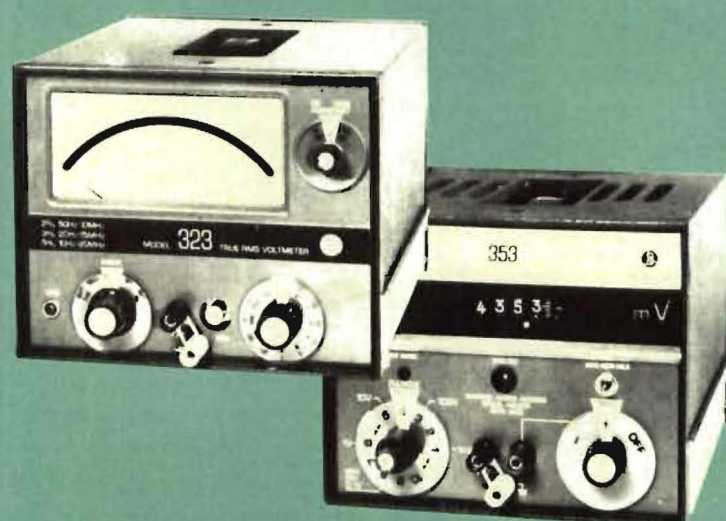




Ballantine electronic instruments



BALLANTINE LABORATORIES Inc. • Boonton, New Jersey

BALLANTINE VOLTMETERS

and other Electronic Measuring Instruments

MODEL NUMBER	VOLTAGE RANGE	FREQUENCY RANGE	ACCURACY		NOTES
			% OF READING	EQUIVALENT % OF F.S. AT MID SCALE	
ANALOG VOLTMETERS, AMMETERS, OHMMETERS					
Average-responding vm's, calibrated in RMS of sine wave					
300E	300 μ V-300 V	30 Hz-200 kHz	2	1	9½ in. wide panel, isolated chassis
300G	1 mV-1 kV	10 Hz-250 kHz	1	½	Highest accuracy vtm in the line
300H	30 μ V-330 V	10 Hz-1 MHz	2	1	Highest sensitivity vtm in the line
300M	500 μ V-500 V	15 Hz-0.5 MHz	2	1	Sealed, militarized type
303	100 μ V-350 V	2 Hz-6 MHz	1	½	Solid state, choice of battery or line operated
302C	100 μ V-1 kV	2 Hz-150 kHz	3	1½	Battery-operated, accurate to 2 Hz. Batt. inc.
310B	100 μ V-300 V	10 Hz-6 MHz	2	1	Wide band, sensitive vtm
314A	100 μ V-1 kV	10 Hz-6 MHz	2	1	Wide band vtm with 10 M Ω probe
317	300 μ V-350 V	10 Hz-11 MHz	2	1	Exceptionally wide band, with 10 M Ω probe
Peak, or peak-to-peak vm's					
305A	1 mV-1 kV	5 Hz-0.5 MHz	2	1	Pos. or neg. peaks, or P-P
316	20 mV-200 V	0.01 Hz-30 KHz	3	1½	P-P, infrasonic to as low as 0.01 Hz
True-RMS vm's					
320A	10 μ V-330 V	5 Hz-4 MHz	2	1	Sensitive, accurate to 5 Hz
323	100 μ V-330 V	10 Hz-20 MHz	2	1	Wide band, solid state, choice of batt. or line operated
340	300 μ V-3(300)V	0.1 MHz-2 GHz	4	2	Calibrated to 700 MHz. Useful to 2 GHz
350	0.1 V-1199 V	50 Hz-20 kHz	0.25	---	Highest accuracy for true-rms measurements
True-RMS/Average/Peak vm					
321	10 μ V-330 V	5 Hz-4 MHz	2	1	Choice of 3 types of measurements
DC Voltage and Current meter					
365	1 μ V-1000 V		1	½	Most accurate available
	0.001 μ A-1 A		2	1	
DC/AC VOLT/OHMMETER					
345	0-1 kV dc		1	½	Highest accuracy volt ohmmeter
	0-350 V ac	20 Hz-1 GHz	2	1	
	0-5000 M Ω		3	1½	

DIGITAL VOLTMETERS

Model 353 0 to 1000 V dc, 4 digit with over-range to 5, plus interpolation of last digit

Accuracy 0.02% + 0.01% f.s., ½ rack module

Model 355 0 to 1000 V ac or dc, 3 digit with over-ranging to 4, plus interpolation of last digit

Accuracy 0.25% f.s. to 500 V, ½ rack module

CALIBRATORS, AC/DC, PORTABLE

Model 420 0 to 10 V dc, or ac at 1000 Hz, RMS, or P-P. Set to any precise value. Accuracy ¼ %

Model 421A 0 to 111 V dc, or ac at 400 or 1000 Hz, RMS or P-P. Accuracy 0.15%. Also 0 to 1110 V ac, 400 Hz, RMS or P-P. Set to any precise value.

AC VOLTAGE STANDARD DEVICES

Model 390 NBS A-T (Attenuator-thermoelement) Voltmeter, 10 MHz-1 GHz, 0.5 V-300 V. Includes Model 2390 Tee.

Model 393 NBS HF Transfer Voltmeter, with six probes, 1 V-100 V, 25 Hz to 30 MHz

Model 440 NBS Micropotentiometer, 4 to 1 range, 15 μ V-1.5 V, 0-900 MHz

AMPLIFIERS, CAPACITANCE METERS, AC TO DC LINEAR CONVERTERS

Model 220C Amplifier, gain of 10 or 100, 10 Hz to 150 kHz, battery-operated and included

Model 520 Capacitance Meter, direct reading 0.01 pF to 13 μ F. Includes accessories

Model 710A AC to DC Linear Converter, 1 mV-1 kV, 30 Hz-250 kHz, 1 V to 10 V each decade

Write for brochures giving many more details



BALLANTINE LABORATORIES - BOONTON - N. J.

Phone: 201-334-1432 TWX: 710-987-8361



FOREWORD

Ballantine Laboratories, Inc. has specialized in the design, manufacture, and sale of electronic measuring instruments since 1932. It has long been a member of the Scientific Apparatus Makers Association to which the leading instrument manufacturers belong.

All Ballantine instruments designed since 1958 show the most important specifications on the nameplate where they will remain for the life of the instruments. To the best of our knowledge this is a unique practice.

Ballantine now manufactures both dc and ac instruments.

BALLANTINE MANUFACTURING POLICY

All Ballantine products are engineered and manufactured up to a standard of quality and not down to a competitive price.

The quality of Ballantine products is guaranteed by our long experience in design, our meticulous control of manufacturing steps, and careful calibration and testing of the finished product.

The Ballantine reputation for manufacturing integrity results from a policy of:

1. Purchasing the highest quality raw materials and components
2. Carefully inspecting and testing these parts before incorporating them into the product
3. Employing only expert personnel working under most favorable working conditions
4. Making a preliminary check for accuracy of each instrument after it comes off the assembly line
5. Then putting each instrument through an appropriate aging cycle to assure its freedom from latent defects
6. Then carefully calibrating each instrument throughout its frequency and voltage range
7. Then putting each instrument through a second aging cycle, and
8. Finally cross-checking each instrument for stability and accuracy, usually on a separate calibration console by a different operator

WARRANTY

We warrant each instrument sold by us to be free from defects in material and workmanship. Our obligation under this warranty is limited to repairing or replacing any instrument or part thereof, except tubes or batteries, which shall within 1 year after shipment to the original purchaser prove upon our examination to be defective.

GENERAL

Terms

Net 30 days, F.O.B. Boonton, New Jersey. For prices consult current price list.

Shipping

Unless otherwise instructed, we ship by Railway Express since our experience has shown that to be the safest way.

Packing

No charge is made for packing for shipments to points in the Continental United States and Canada. An extra charge is made for the special export packing required for shipments to other points.

Claims for Damage in Shipment

If any instrument arrives in a damaged condition, a claim

should be filed immediately with the carrier. Then advise us as to the extent of the damage and await our instructions before returning the instrument to us for repair.

Shipments to Ballantine Laboratories, Inc.

If it is desired to return instruments to us for repair, re-calibration or any other reason please write us first for shipping instructions and give model and serial number of the instrument, and reason for return.

Additional Information

Our Engineering Department is always glad to supply any additional technical information required on any of our instruments or to render advice on any special problems encountered in the measurement of voltage, current and other electrical parameters.

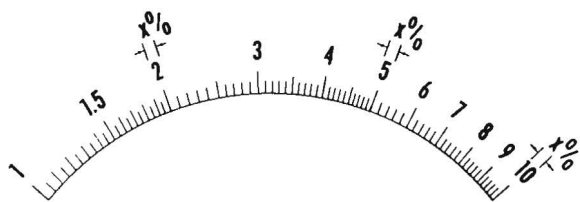
WHY BALLANTINE USES LOGARITHMIC SCALES

Ballantine electronic voltmeters, ammeters, ohmmeters and capacitance meters employ indicating meters having logarithmic scales which result in

- 1. Uniform accuracy in % of indication over the entire scale length
- 2. Uniform resolution in % of indication over the entire scale length

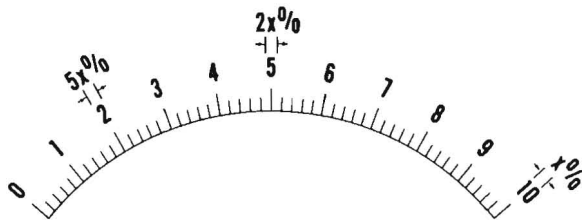
A comparison of the Ballantine logarithmic scale with the conventional linear scale follows:

THE BALLANTINE LOGARITHMIC SCALE



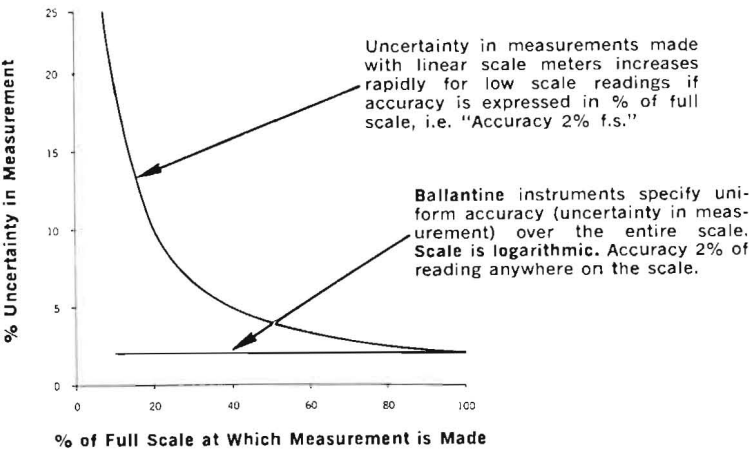
In a logarithmic meter, pioneered and used by Ballantine since 1936, the same angular deviation produces a constant $x\%$ error in indication at any point of the scale. The meter readings are uniformly accurate throughout its range. At the low end of the scale the constant angular error represents the same % of the reading as it does at any other point on the scale.

CONVENTIONAL LINEAR METER SCALE



In a conventional linear meter movement, a small angular deviation, which may represent an error of $x\%$ scale indication, becomes a $2x\%$ error at midpoint and a $5x\%$ error at 2. The lower third of such a meter is practically useless despite the fact that the meter may be rated at better than $x\%$ accuracy fsd (full scale deflection).

This curve shows the uncertainty in the measurement for a linear scale voltmeter rated at 2% of full scale, and for a Ballantine logarithmic scale voltmeter, rated at 2% of reading.



DECADE AMPLIFIER - MODEL 220C

Frequency: 10 cps - 150 kc

Gains: x10 & x100

Full specifications below

GENERAL

The Model 220C Decade Amplifier was originally designed for use with the Ballantine Model 300 Electronic Voltmeter in order to increase further its sensitivity thereby permitting the measurement of alternating potentials as low as 20 microvolts over a frequency range of 10 to 150,000 cps. It provides stabilized voltage amplifications of precisely 10 or 100 either of which may be selected by a panel-mounted switch. It is powered by self-contained readily available commercial batteries having a life of over 150 hours with normal use. A meter is provided on the panel for testing the condition of the batteries.

An important application of the Model 220C Amplifier and the Model 300 Voltmeter is in low level noise measurement such as is exemplified in the test methods of specification JAN-R-11. The amplifier may be used within the limits of its frequency response of 10 to 150,000 cps with other Ballantine Voltmeters or for other applications when stable voltage gains of 10 or 100 are desired.

DESCRIPTION

The amplifier comprises two stages and utilizes overall negative feed-back to stabilize the gain so that normal variations of battery voltages, changes in tubes and other circuit parameters do not affect the gain by more than 2%. Negative feedback provides relatively low source impedances at the amplifier output terminals for the two gain settings, thus allowing the amplifier to operate effectively into loads lower than those imposed by the input impedance of voltmeters. However, if the output of the amplifier is fed into loads having a shunt capacitance greater than 30 pF or a resistance lower than $\frac{1}{2}$ megohm (these figures applying to the Model 300 Voltmeter) its gain may vary beyond the specified limits of 2% at the extreme ends of the frequency range.

Although designed for dealing with microvolt levels, voltages up to 50 millivolts may be impressed across the input terminals of the Model 220C without affecting its strictly linear response.

When used with most types of Ballantine voltmeters (including the Model 300) the available gain of the amplifier should nominally allow levels down to 10 micro-



volts to be measured. But the irreducible random input noise of the amplifier arising from Johnson and shot effects is approximately 8 microvolts; and this quantity sets the lowest measurable limit at 25 microvolts if the error is not to exceed 10%. Corrections could be applied for lower levels but unless the meter in the measuring system is heavily damped the fluctuations of the pointer would preclude such measurement. These restrictions would be considerably mitigated if a narrow-band filter were inserted between the amplifier and its associated voltmeter. Various heterodyne type harmonic analyzers are also commercially available which may be used as selective voltmeters in conjunction with the Model 220C Decade Amplifier to effect reliable measurements even below 10 microvolts.

The physical design of the decade amplifier includes a double system of anti-microphonic mounting for the input tube so as to greatly reduce the effects of mechanical shock and vibration when the amplifier is employed in low level service.



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SPECIFICATIONS — MODEL 220C

Voltage Gain: 10 times or 100 times. Gain accuracy 2%.

Frequency Range: 10 cps-150 kc.

Input Impedance: 5 megohms shunted by 15 pF.

Output Impedance: Less than 900 ohms in series with 2 μ F for x10 gain; less than 7,000 ohms in series with 2 μ F for x100 gain.

Inherent Noise: 8 microvolts approx. referred to series grid circuit of first tube stage. (Additional noise in the shunt circuit will arise depending on the internal impedance of the signal source. Thus the total noise with input terminals open circuited but covered with a grounded shield is 25 microvolts approx.).

Batteries: Two Eveready type 742; two Eveready type 467 — all batteries supplied.

Tubes: Two type 1U4.

Standard Finish: Panel black crackle, box black wrinkle.

Dimensions: 4½" high, 5¾" wide, 8¾" long.

Weight: 7¾ pounds complete with batteries.

Shipping Weight: Portable 13 pounds; Rack 23 pounds.

SPECIAL VERSIONS OF THE MODEL 220C

The following special version is available at a small increase in price. Delivery period information may be obtained from Ballantine Laboratories, Inc., or any of its field sales representatives. Inquiries are solicited in respect to other special modifications to suit customers' preferences.

<i>Model No.</i>	<i>Brief Description of Special Version</i>
220C-S/2	Electrically similar to basic Model 220C but mounted on a 19" x 7" x 1½" relay rack panel.

Both the standard Model 220C and the rack panel mounted version can also be supplied with special paint finishes to meet specific requirements.



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ELECTRONIC VOLTMETER — MODEL 300E

Voltage range: 300 μ V to 300 V

Frequency range: 30 cps to 200 kc

FEATURES

- **COMPACT, RUGGED, MINIMUM PANEL SPACE**
- **PANEL ISOLATION FOR SYSTEMS GROUNDING**
- **LONG LIFE**
- **OUTSTANDING STABILITY**
- **HIGH INPUT IMPEDANCE**
- **LARGE EASY TO READ METER**
- **HIGH ACCURACY AT ANY POINT ON SCALE**

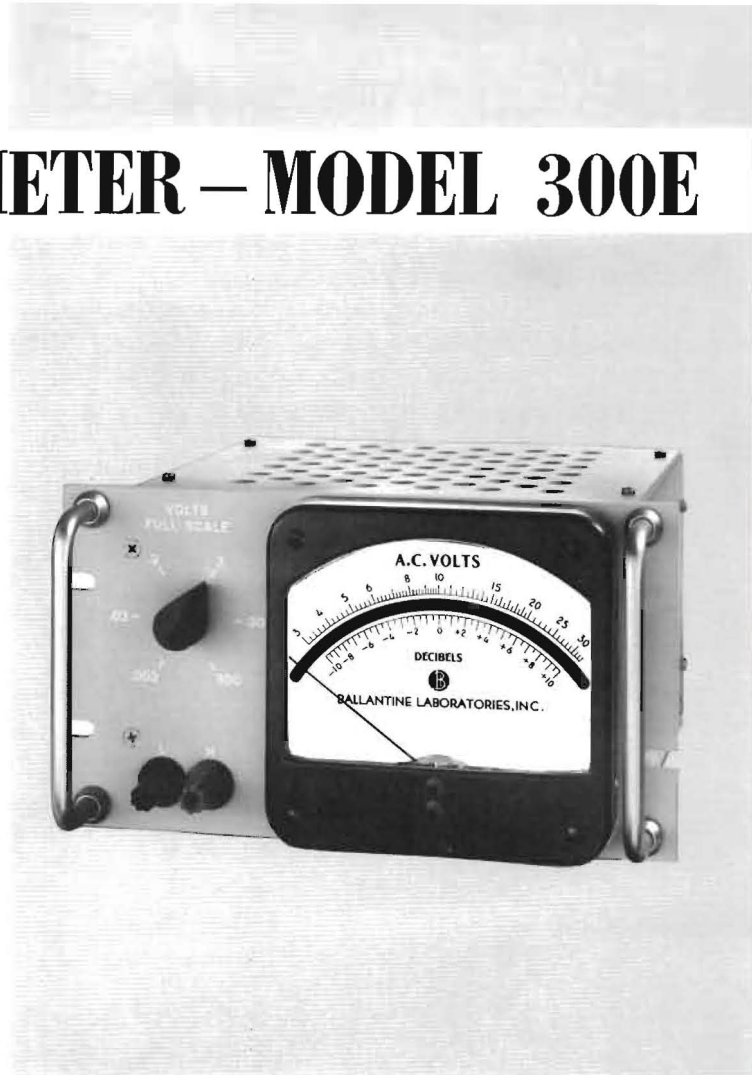
GENERAL DESCRIPTION

The Model 300E has been designed to meet the demand for a "systems" voltmeter, i.e., a voltmeter for incorporation as a unit of a larger piece of measuring or test equipment. It is available in both full and half-width relay rack panels of 5 $\frac{1}{4}$ " height. Provision is made so that the signal input may be connected to input terminals at the front of the instrument, or to a BNC (UG-290-U) jack at the rear. The panel is isolated from the chassis or signal ground, for ultimate connection to a separate systems ground. The range switch shaft is extended at the rear to permit adaptation to automatic programming.

Essentially the Model 300E comprises a high impedance attenuator followed by a feedback stabilized amplifier which feeds an average responding rectifier-meter circuit.

The attenuator unit employs hermetically sealed film type resistors of advanced design. These resistors while exhibiting a stability approaching that of wire wound units, are free from the reactive effects inherent in the latter. By further matching temperature coefficients of the various resistors and selecting initial tolerances of $\pm 0.1\%$, an attenuator displaying high accuracy, long term stability, and small frequency response error is achieved.

The amplifier section of the voltmeter consists of four stages, employing both local and overall feedback. The amount of feedback is sufficient to maintain the instrument accuracy with changes in line voltage, tube characteristics, temperature, etc. To assure long life, all tubes as well as all other components in the instrument are operated well below their maximum ratings. Tests conducted at Ballantine Laboratories, Inc. indicate that



the instrument will maintain its specified accuracy without recalibration or tube replacement for several thousands of hours of use.

The frequency range of the instrument extends to approximately 1 megacycle over which range the instrument is useable as an indicator. The calibrated range of the instrument is 30 cps to 200 kc, and in this range it is accurate within 2% to 100 kc and 3% above 100 kc.

To reduce errors caused by hum when measuring voltages of line frequency, the heater of the first amplifier stage is operated on dc.

The signal rectifier utilizes hermetically sealed silicon diodes which are virtually immune to shock, vibration, temperature and aging effects. Since the rectifier circuit is included in the feedback loop, excellent linearity is obtained over the entire 20 db range.

The indicating meter employs shaped pole pieces to achieve a logarithmic characteristic over a 10 to 1 voltage range. The large 5 inch mirror-backed scale has a 10% extension at the high end, to reduce the amount of switching necessary when working at or near the end point of the scale. It should be noted that the specified accuracy applies to any point on the meter scale, as



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opposed to full scale accuracy specifications for linear meters, where the error increases proportionally when less than full scale indications are read.

The power supply uses a single gaseous tube as a simple and reliable voltage regulator. The dc heater supply for the first amplifier tube uses hermetically sealed silicon junction diodes.

ADDITIONAL FEATURES

An amplifier output is available at a pair of terminals at the rear of the voltmeter. The gain is approximately 46 db, the maximum output approximately 0.6 volt, and the source impedance approximately 300 ohms. The output has some distortion and shows nonlinearity with

amplitude, however, it can be used for approximate observation of waveforms.

To permit operation as a null detector, a switch leg is available at a pair of rear mounted terminals. Closing the terminal causes the meter indication to be biased to an on-scale position even in the absence of signal.

Also available at rear mounted terminals are 6.3 volts ac at 0.3 ampere (line frequency), and 250 volts dc at 1 milliampere.

Mechanically the instrument has been designed for compactness, high mechanical strength, and accessibility for servicing. The instrument is very carefully calibrated on all voltage ranges and at all frequencies. All components are 100% inspected before assembly and each completed instrument must satisfactorily pass several aging and heating cycles to insure its stability and permanency of calibration accuracy.

SPECIFICATIONS MODEL-300E ELECTRONIC VOLTMETER

Voltage Range—300 microvolts to 300 volts in 6 ranges, in steps of 20 db.

Frequency Range—30 cps to 200 kc.

Accuracy—2% at any point on meter scale, 30 cps-100 kc; 3% 100 kc-200 kc.

Input Impedance

Range	R	C
0.003 volts	2,000,000 ohms	40 pF
0.03 "	2,000,000 ohms	30 pF
0.3 "	2,000,000 ohms	20 pF
3.0 "	2,000,000 ohms	20 pF
30.0 "	2,000,000 ohms	20 pF
300.0 "	2,000,000 ohms	20 pF

Amplifier—Max. gain is approximately equal to 46 db; response is ±1 db 30 cps to 100 kc; maximum voltage is approximately 0.6 volt from source of approximately 300 ohms.

Null Detector—Meter is biased on scale when switch leg available at rear terminal board is closed.

Auxiliary Outputs—6.3 volts (line frequency) at 0.3 amps, and 250 volts DC at 1 mA (available at rear terminal strip).

Input Connections—Binding posts on front panel; BNC connector in rear.

Front Panel Isolation—The front panel is isolated from signal-ground for ultimate connection to systems ground.

Adjustments—Sensitivity and scale decading available through access holes in instrument case.

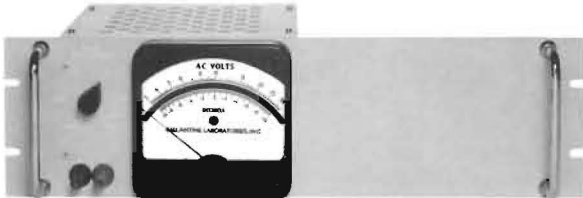
Power Supply—105 V to 125 V, 60-400 cps, 37 watts.

Dimensions (inches)—5¼ H x 9½ W x 9½ D.

Weight (pounds)—10.

Shipping Weight (pounds)—15.

SINGLE AND DUAL UNITS ON A 19 INCH PANEL



A Single Model 300E on a 19 inch panel is designated

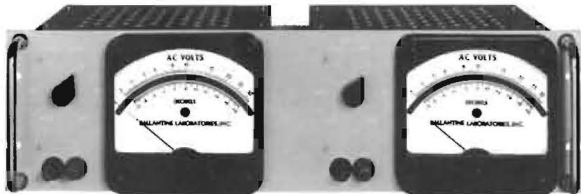
Model 300E-S2

Color of standard panel is gray.

Dimensions (inches) are 19 W x 5¼ H x 9½ D.

Weight (pounds)—11.

Shipping Weight (pounds)—26.



Two Model 300E's on a 19 inch panel is designated

Model 300E-U2

Color of standard panel is gray.

Dimensions (inches) are 19 W x 5¼ H x 9½ D.

Weight (pounds)—19.

Shipping Weight (pounds)—34.



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ELECTRONIC VOLTMETER—MODEL 300G

Volts: 0.001 volt to 1000 volts
Frequency: 10 cps to 250,000 cps
Full specifications below

FEATURES

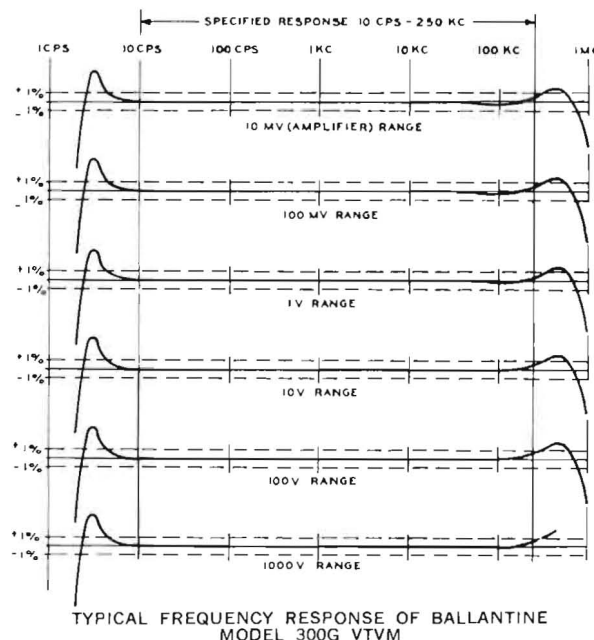
- **HIGH ACCURACY WITH LONG TERM STABILITY**
1% OF READING
20 cps—20 kc, 1 mV—250 V
- **LARGE, EASY-TO-READ METER**
- **HIGH INPUT IMPEDANCE**
- **MOST ACCURATE VTVM AVAILABLE IN THIS VOLTAGE AND FREQUENCY RANGE**
- **AVAILABLE IN RACK VERSIONS, ANY COLOR**

GENERAL DESCRIPTION

The Ballantine Model 300G is the *only* commercially available direct reading vacuum tube voltmeter to offer 1% accuracy at all points on the meter scale over the frequency range of 20 cps to 20,000 cps, and the voltage range of 1 millivolt to 250 volts. It is not to be confused with instruments which may specify 1% accuracy only at full scale and lesser accuracy at all other points on scale; neither should the 300G be confused with potentiometric type instruments which require nulls, balances, etc., to be achieved before readings can be taken. The Model 300G is direct reading (only one range knob to manipulate) and provides the accuracy specified at *all points on the meter scale*. Moreover the design of the Model 300G is such that it may be expected to maintain specified accuracy for several thousand hours of use, without recourse to recalibration, tube replacement etc.

The Model 300G comprises a high impedance attenuator followed by a feedback stabilized amplifier which feeds an average responding rectifier-meter circuit.

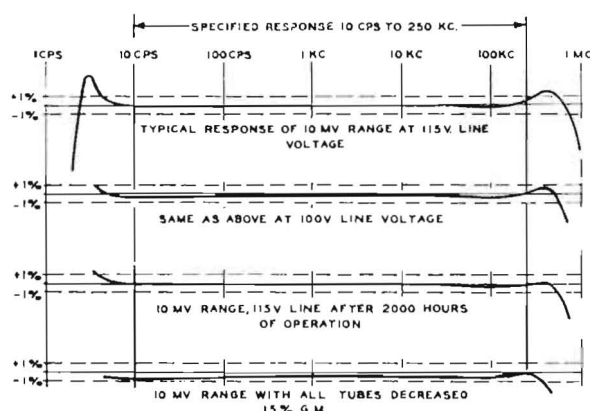
The attenuator unit uses hermetically sealed film type resistors of advanced design. These resistors, while exhibiting a stability approaching that of wire wound resistors, are free from reactive effects inherent in the latter. By further matching the temperature coefficients of the various resistors and selecting initial tolerances of $\pm 0.1\%$, an attenuator displaying high accuracy, long term stability, and small frequency response error is achieved. A typical frequency characteristic of the voltmeter including attenuator, amplifier, and rectifier circuit is shown on the accompanying graph.



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The amplifier section of the voltmeter consists of four stages, employing both local and overall feedback. The amount of feedback (40 db) is sufficient to maintain the instrument accuracy with changes in line voltage, tube characteristic changes, etc. The tubes, as well as all other components in the instrument, are operated well below their maximum ratings which assures long life. Tests conducted at Ballantine Laboratories have indicated that the instrument will maintain its specified accuracy without recalibration and tube replacement for over several thousands of hours of use.

The effects of line voltage variations, on-off cycling, and tube changes are pictured on the graph below. The very small change in accuracy after 2000 hours (1 year normal use) of operation should be noted.



TYPICAL STABILITY OF BALLANTINE
MODEL 300G VTVM

The frequency range of the amplifier extends to approximately 1 megacycle, over which range the instrument is usable as an indicator. The calibrated range of the instrument is 10 cps to 250 kc, and in this range the instrument exhibits excellent stability and very little variation in response.

By means of a function switch and an output jack the instrument may be used as an amplifier with a maximum voltage gain of 60 db, ± 1 db, adjustable in steps of 20 db by means of the input attenuator. The output impedance of the amplifier is approximately 300 ohms. A distortion free output is obtainable with load impedances as low as 15,000 ohms. The noise level at the output of the amplifier is approximately 50 millivolts.

The indicating meter uses shaped pole pieces to achieve a logarithmic characteristic over a 10 to 1 voltage range. The large 5 inch mirror-backed scale with a 10 to 1 range has a 10% extension at both ends to reduce the amount of switching necessary when working at or near the end points of the scale. The basic meter error is less than $\pm 0.5\%$ at all points on scale, thus permitting a 1% instrument accuracy specification with considerable reserve. It should be noted that this accuracy applies to all points on the scale, contrary to full scale specifications for linear meters where the error increases proportionally when less than full scale readings are taken.

Mechanically, the instrument has been designed for compactness, high mechanical strength, and accessibility for servicing. Exclusive of the indicating meter, the voltmeter successfully passes the vibration test as outlined in Military specification MIL T-945A. All instruments are very carefully calibrated on all voltage ranges and at all frequencies. All components are 100% inspected before assembly and each completed voltmeter must satisfactorily pass several aging and heating cycles before being shipped to insure its stability and permanency of calibration accuracy.



Relay Rack Version, 300G-S2

SPECIFICATIONS — MODEL 300G

Voltage Range: 1 millivolt to 1000 volts rms in 6 decade ranges. (.01, .1, 1, 10, 100 and 1,000 volts full scale).

Frequency Range: 10 to 250,000 cps.

Accuracy: 20 cps to 20,000 cps and 1 millivolt to 250 volts...1%
10 cps to 250,000 cps and 1 millivolt to 1,000 volts .2%
at all points on the meter scale.

Input Impedance: 2 megohms shunted by 15 pF except 25 pF on most sensitive range.

Decibel Range: -60 to +60 decibels referred to 1 volt.

Stability: Less than $\frac{1}{2}\%$ change with power supply voltage variation from 105 to 125 volts.

Scales: Logarithmic voltage scale reading from 1 to 10 with 10% overlap at both ends; auxiliary linear scale in decibels from 0 to 20. Each meter is hand calibrated.

Amplifier Characteristics: Maximum voltage gain of 60 db; maximum output 10 volts; output impedance is 300 ohms. Frequency response flat within 1 db from 10 to 250,000 cps.

Power Supply: 115/230 volts, 50-420 cps, 35 watts approx.

Standard Finish: Panel gray crackle, box gray wrinkle.

Dimensions: Portable: 11" H, 6" W, 7" D.
Rack: 6 $\frac{3}{4}$ " H, 19" W, 6" D.

Weight: Portable 10 pounds, rack 11 pounds.

Shipping Weight: Portable 13 pounds, rack 26 pounds.



Printed in U.S.A.

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6-65-Y-7

ELECTRONIC VOLTMETER-MODEL 300H

REPLACES THE MODEL 300D

Voltage: 30 microvolts to 330 volts
Frequency: 10 cps — 1 Mc
Full specifications below

FEATURES

- **TEN MILLION-TO-ONE VOLTAGE RANGE**
- **ONE HUNDRED THOUSAND-TO-ONE FREQUENCY RANGE**
- **LARGE EASY TO READ METER, INDIVIDUALLY CALIBRATED**
- **SAME HIGH ACCURACY AT ALL POINTS ON THE SCALE**
- **LONG LIFE WITHIN SPECIFIED ACCURACY**
- **OUTSTANDING STABILITY**
- **HIGH INPUT IMPEDANCE**
- **AVAILABLE IN RACK VERSIONS, ANY COLOR**

GENERAL DESCRIPTION

The Model 300H is a general purpose, precision, laboratory electronic ac voltmeter designed to operate for extended periods of time with freedom from recalibration and servicing. The design is based on that of the original Ballantine Model 300 Voltmeter and places emphasis on improvements in stability, reliability, readability, and increased frequency coverage. Model 300H replaces the 300D, providing a wider frequency coverage and greater sensitivity.

Essentially, the Model 300H comprises a high impedance attenuator followed by a feedback stabilized amplifier which feeds an average-responding rectifier-meter circuit.

The attenuator unit employs hermetically sealed film type resistors of advanced design. These resistors, while exhibiting a stability approaching that of wire wound resistors, are free from reactive effects inherent in the latter. By further matching the temperature coefficients of the various resistors and selecting initial tolerances of $\pm 0.2\%$, an attenuator displaying high accuracy, long term stability, and small frequency response error is achieved. A typical frequency characteristic of the voltmeter including attenuator, amplifier, and rectifier circuit is shown in Fig. 1.

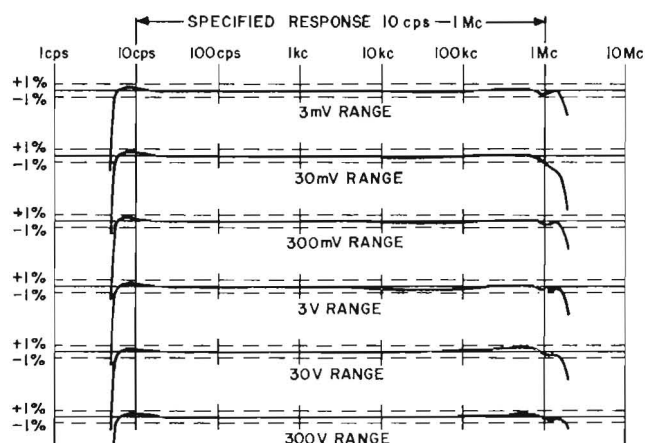


FIG. 1

Typical Frequency Response of Ballantine Model 300H VTVM



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The amplifier section of the voltmeter consists of four stages, employing both local and overall feedback. The amount of feedback (40 db) is sufficient to maintain the instrument accuracy with changes in line voltage, tube characteristic changes (up to 15% in gm of all tubes), etc. The tubes, as well as all other components in the instrument, are operated well below their maximum ratings, assuring long life. Tests conducted at Ballantine Laboratories have indicated that the instrument will maintain its specified accuracy without recalibration and tube replacement for several thousands of hours of use.

The effects of line voltage variations, on-off cycling, and tube changes are shown in Fig. 2. The very small change in accuracy after 2000 hours (1 year normal use) of operation should be noted.

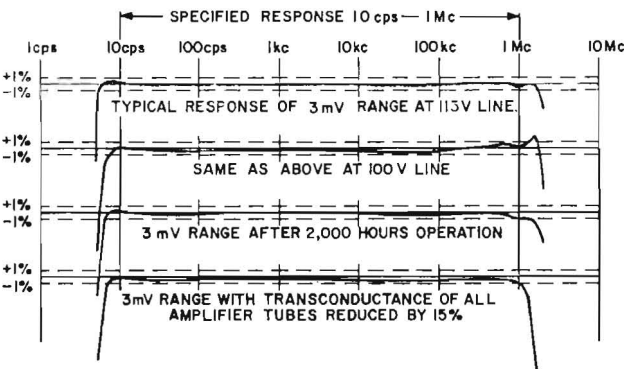


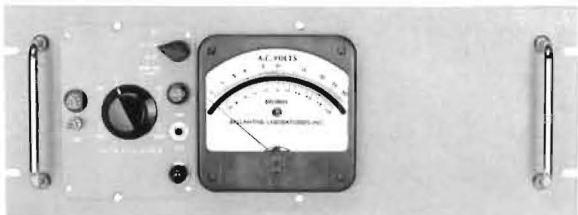
FIG. 2
Typical Stability of Ballantine Model 300H VTVM

Operating the heater of the first amplifier stage on dc, greatly reduces the hum injected at this low-level point.

By means of a function switch and an output jack the instrument may be used as an amplifier with a maximum voltage gain of 40 db, adjustable in steps of 20 db by means of the input attenuator. The output impedance of the amplifier is approximately 3 ohms. A distortion free output is obtainable with load impedance as low as 5,000 ohms. The noise level at the output of the amplifier is approximately 2.5 millivolts.

The SENS X10 position of the function switch increases the basic sensitivity of the instrument by a factor of 10, thus permitting measurements down to 30 microvolts.

Mechanically, the instrument has been designed for compactness, high mechanical strength, and accessibility for servicing. Exclusive of the indicating meter, the voltmeter successfully passes the vibration test as outlined in Military Specification MIL T-945A. Every instrument is carefully calibrated on all voltage ranges and at all frequencies. All components are inspected before assembly and each completed voltmeter must satisfactorily pass several aging and heating cycles to insure its stability and permanency of calibration accuracy.



Relay Rack Version, 300H-S2

SPECIFICATIONS — MODEL 300H

- Voltage range:** 30 microvolts to 330 volts.
- Frequency range:** 10 cps to 1 Mc.
- Accuracy; at all points on scale.**
 - 300 μ V to 300 V: 10 cps to 700 kc 2%
 - 700 kc to 1 Mc 3%
 - 30 μ V to 300 μ V: (in SENS X10 position) the accuracy is 5% for frequencies 100 cps to 100 kc. Measurements above and below this band may be made with reduced accuracy, as shown in Figure 3
- Input impedance:** 2 megohms shunted by 15 pF except 25 pF on the most sensitive range.
- Decibel range:** -90 to +50 db referred to 1 volt.
- Stability:** Change in indication with power supply variation from 115 \pm 10 volts.
 - <0.25% 20 cps to 500 kc
 - <0.50% 10 cps to 700 kc
 - <0.75% 10 cps to 1 Mc

- Null detector (SENS X10):** Sensitivity—30 microvolts minimum indication.
- Scales:** Logarithmic voltage scale reading from 3 to 33; linear decibel scale from -10 to +10.
- Amplifier characteristics:**
 - Maximum gain 40 db, \pm 1 db
 - Maximum output 0.3 volt
 - Output impedance 3 ohms
 - Minimum load impedance 5,000 ohms
 - Response \pm 1 db, 10 cps to 1 Mc
 - Noise (referred to open circuit input terminals) 25 μ V max.
- Tubes:** Four type 6AU6, one type OA2, and one type 6X4.
- Power supply:** 115/230 volts, 50-420 cps, approx. 35 watts.
- Standard finish:** Panel, gray crackle; box, gray wrinkle.
- Dimensions:** Portable: 11" H, 6" W, 7" D.
Rack: 6 $\frac{3}{4}$ " H, 19" W, 6 $\frac{1}{2}$ " D.
- Weight (lbs.):** Portable 10; rack 11.
- Shipping Weight (lbs.):** Portable 13; rack 26.



BALLANTINE LABORATORIES - BOONTON - N. J.

ELECTRONIC VOLTMETER-MODEL 300M

Voltage range: 500 μ V to 500 V

Frequency range: 15 cps-400 kc

FEATURES

- **SEALED FOR ROUGH "OUTDOORS" USE ON LAND, SEA, OR AIR**
- **EXCELLENT FOR USE IN ENVIRONMENT OF MOISTURE, DUST, FUMES, VIBRATION**
- **HIGH ACCURACY WITH LONG-TERM STABILITY**
- **INDIVIDUALLY-CALIBRATED LOG-ARITHMIC SCALE PROVIDES UNIFORM PRECISION AND ACCURACY OVER ITS ENTIRE LENGTH**

GENERAL DESCRIPTION

The Model 300M was originally designed for use as part of an outdoors check-out system for a missile.

The requirement was for an accurate sensitive instrument that could withstand rough handling and yet perform satisfactorily over long periods of outdoors, on-the-site operation. The resulting Model 300M is ruggedized and completely sealed with silicone rubber gaskets, O-rings and wedge clamps. The final test for sealing involves pressurizing the inside and immersing the entire instrument in water in the manner of looking for a leak in an automobile inner tube. There must be no visible leaks. This construction makes it possible to withstand the wind-driven rain, and salt spray tests with ease. Of course it is also free from adverse effects of dust, fumes, and severe humidity. The internal mechanical design prevents damage under the vibration and shock of military environment tests. The electrical design is similar to the Ballantine Model 300G so well known in the industry for accuracy and long term stability.

The indicating meter employs shaped pole pieces to achieve a logarithmic response over a 10 to 1 voltage range. Every instrument is hand-calibrated and this, together with the logarithmic response, makes possible an instrument having uniform accuracy *and* precision of reading over its entire scale. No part of the scale is wasted. The following graph shows the uniform "uncertainty" or "maximum allowable error" on a Ballantine log scale meter compared to that for a linear scale instrument having the same accuracy at full scale but rated in terms of % of full scale deflection (f.s.d.).

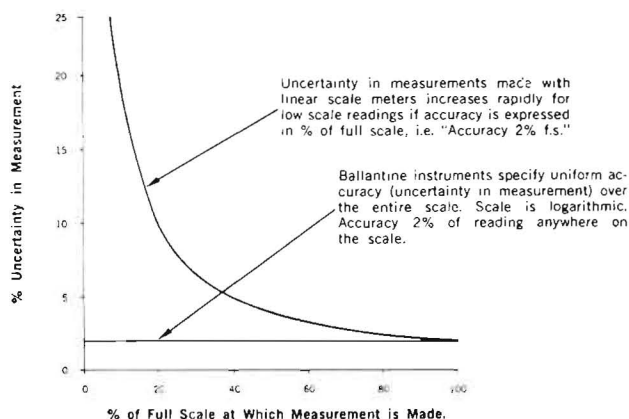


Figure 1. This curve shows the uncertainty in the measurement for a linear scale voltmeter rated at 2% of full scale, and for a Ballantine logarithmic scale voltmeter, rated at 2% of reading.



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Model 300M has a high impedance input attenuator, followed by a feedback-stabilized amplifier, which in turn feeds an average-responding meter-rectifier circuit. The meter is calibrated in rms of a sine wave.

High feedback over more than the specified frequency range, and conservatively operated tubes and components, assures a long life within specifications. It also makes possible replacement of tubes with negligible effect on the accuracy over the entire frequency band. The following graph shows the frequency response for a typical Model 300M at normal power line voltage, at 100 volts line voltage, and at normal power line voltage but with all amplifier tubes having transcon-

ductance of 15% lower than rated value. Note that the response shown on all curves exceeds specifications.

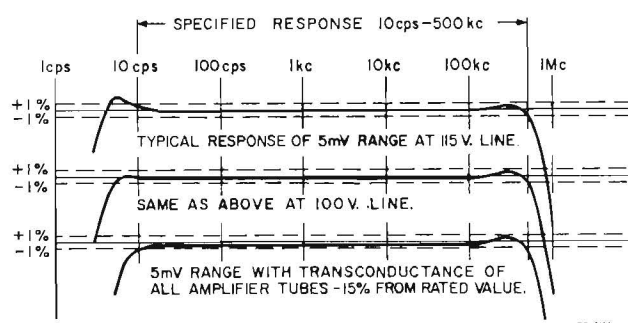


Figure 2. Typical frequency response of Model 300M.

SUGGESTED USES

The feature of being completely sealed as well as rugged, makes the Model 300M useful in military field applications, shipboard applications, for microwave ap-

plications, underground telephone, mining operations, or factory operations where there is a concentration of fumes or dust, or where there may be much vibration.

SPECIFICATIONS

Voltage range: 500 μ V to 500 V, in 6 decade ranges.

Frequency range: 15 cps to 400 kc (3 db bandwidth is typically 5 cps to 1 Mc).

Accuracy: 15 cps to 250 kc—2% of indication, anywhere on the scale. 250 kc to 400 kc—4% of indication, anywhere on the scale.

Indication: Average, calibrated in RMS of sine wave.

Safe operating ambient temperatures: -40°C to $+52^{\circ}\text{C}$.

Input impedance: 2 megohms shunted by 20 pF except 30 pF on most sensitive range.

Decibel range: -64 to $+56$ db, reference 1 mW into 600 ohms.

Stability: Change in indication with line voltage variation of 115 V ± 10 V. 15 cps—300 kc, $\pm 0.5\%$ max. 300 kc to 400 kc, $\pm 1.0\%$ max.

Scales: Logarithmic voltage scale from 0.49 to 5. Linear decibel scale from -4 to $+16$. 0 db reference is 0.775 volt (1 mW into 600 ohms).

Power supply: 115/230 V, 50-420 cps, 38 watts.

Color: Gray.

Dimensions: 6" wide x 6 $\frac{5}{8}$ " deep x 11 $\frac{3}{8}$ " long.

Weight: 12.5 pounds.



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Printed in U.S.A.

11-65-Y-2

BATTERY OPERATED ELECTRONIC VOLTMETER MODEL 302C

Volts: 100 microvolts - 1000 volts

Frequency: 2 - 150,000 cps

Full specifications below

GENERAL

The fact that the Model 302C voltmeter is powered by its own batteries makes it particularly useful in cases either where no external AC power source is available or where it is not desirable to use such a source because of limitations imposed by even a small amount of residual 60 cps line frequency hum. The Model 302C is particularly useful where measurements are to be made in ungrounded or symmetrical circuits.

While possessing unsurpassed voltage sensitivity for a battery-operated instrument, inasmuch as it measures down to 100 microvolts, the Model 302C permits measurements to be made from 2 cps through 150kc with high input impedance as described in the electrical specifications below.

DESCRIPTION

This voltmeter offers all the features and advantages of the well-known Ballantine principles of electronic voltmeter operation. It employs a resistance-capacity decade attenuator, a high gain negative feedback stabilized amplifier system, a rectifier and a logarithmic indicating meter responding to the average values of the voltage wave but calibrated in RMS values of a sine wave.

To insure stability with high gain, the amplifier consists of two negative feedback units of three stages each. Minimum noise levels are achieved by placing part of the decade attenuator between the two units of the amplifier. The output amplifier incorporates the indicating meter rectifier in its feedback loop with the attending benefits of linearity described in Stuart Ballantine's original disclosure of this type of circuit in the September 1938 issue of "ELECTRONICS".

In order to eliminate needle flutter at the very low frequencies without making the meter response too sluggish at the higher frequencies, a switch is provided for inserting extra meter damping when required. This extra meter damping will also be found useful when making measurements of voltages which are subject to random fluctuations, such as noise potentials, etc. The indicating meter is arranged so that by merely throwing a switch it may be used to check the condition of the batteries. Battery life with normal use (4 hours per day) exceeds 100 hours.

An output jack permits the amplifier section of the voltmeter to be used as a separate decade amplifier which, owing to the complete absence of AC hum, will be found extremely useful as a high gain pre-amplifier for improving the sensitivity of cathode ray oscilloscopes and of other measuring devices. The amplifier has a maximum undistorted output voltage of 1 volt, a maximum gain of 60 DB and an output impedance of about 3000 ohms. The gain is adjustable in steps of 20 DB by means of the



range switch, or may be continuously varied using the output control. The gain of the amplifier when fed into a load having a resistance of not less than 100,000 ohms and a capacitance of approximately 100 pF is uniform within 0.5 DB over the entire range from 2 to 150,000 cps.

The Model 302C is mounted in a light but sturdy aluminum carrying case having a black wrinkle finish and a removable splash-proof cover. It operates from standard commercially available batteries which are placed in the carrying case in such a manner as to be easily replaceable.

AVAILABLE ACCESSORIES

A series of Ballantine products are available to enable the owner of a Model 302C to employ it in extended ranges and other applications.

Accessory Models 220C and 1310B expand the range from 20 microvolts to 10,000 volts rms of a sine wave. The Model 700 allows measurements of direct potentials between 10 microvolts and 100 volts with a detection sensitivity of 1 microvolt, and Model Series 600 shunt resistors furnish means for measuring currents from 0.1 microampere to 10 amperes. The latter application in regard to the Model 302C has the added advan-



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tage of permitting the measurement of current at points in a circuit where it is not permissible to ground either terminal of the shunt resistor.

Further information pertaining to these accessories will be found on separate sheets of the Ballantine catalog.

SPECIFICATIONS — MODEL 302C

Frequency Range: 2 to 150,000 cps.
Voltage Range: 100 microvolts to 1000 volts in 7 decade ranges. (.001, .01, .1, 1, 10, 100 and 1000 volts full scale).
Accuracy: 3% except 5% below 5 cps, above 100,000 cps, and above 100 volts, **at any point on the meter scale.**
Input Impedance: 2 megohms shunted by 25 pF on the two most sensitive ranges and by 10 pF on the other ranges.
Decibel Range: -80 to +40 decibels referred to 1 volt. Special version Model 302C-S/1 has decibel scale referred to 1 milliwatt in 600 ohms (0.775 volts) and covers range -78 to 42 dbm.
Noise Level: Less than 10 microvolts referred to input circuit.
Scales: Logarithmic voltage scale reading from 1 to 10; auxiliary linear scale in decibels from 0 to 20. Each meter is hand calibrated.

Tubes: Five Type 1U4, one Type IR5. All tubes supplied.
Amplifier Characteristics: Maximum voltage gain of 60 DB. Output impedance about 3000 ohms. Maximum output voltage 1 volt. Flat within 0.5 DB.
Batteries: Four Eveready type 467; Four Burgess type 2F. Battery life 100 hours or more in normal use. Batteries supplied.
Standard Finish: Panel is black Crackle. box and cover black Wrinkle.
Dimensions: 6⁷/₈" wide, 7¹/₂" high, 12³/₈" long.
Weight: 15 pounds complete with batteries.
Shipping Weight: 20 pounds; rack 28 pounds.

SPECIAL VERSIONS OF THE MODEL 302C

The following special versions are available at a small increase in price. Delivery period information may be obtained from Ballantine Laboratories, Inc., or any of its field sales representatives. Inquiries are solicited in respect to other special modifications to suit customers' preferences.

<i>Model No.</i>	<i>Brief Description of Special Version</i>
302C-S/1	Electrically similar to basic Model 302C but has decibel scale referred to 1 milliwatt in 600 ohms (0.775 volts). Panel is marked in db as well as in VOLTS FULL SCALE.
302C-S/2	Electrically similar to basic Model 302C but mounted on a 19" x 7" x 1 ¹ / ₈ " relay rack panel.

The standard Model 302C, as well as the modified versions, can also be supplied with special paint finishes to meet specific requirements.



BALLANTINE LABORATORIES - BOONTON - N. J.

SOLID-STATE AC VOLTMETER - MODEL 303

- 1% ACCURACY
- 300 μ V - 350 V
1 mV - 1000 V WITH OPTIONAL PROBE
- 2 Hz - 6 MHz
- RECHARGEABLE BATTERY
- FLOATING SIGNAL GROUND



DESCRIPTION

The Ballantine Model 303 is an all-solid-state ac voltmeter designed to operate from a built-in rechargeable battery or from a power line. Optional versions are available for line only operation.

The frequency range of Model 303 is from 6 MHz down to 2 Hz — a low frequency unequalled in any other solid state voltmeter.

A 1% mid-band accuracy, coupled with a mirror-backed, five-inch, 10 dB logarithmic indicator, allows unmatched reading ease. Voltages can be measured over a range from 300 μ V to 350 V with the same accuracy at any point on the scale. Resolution is also constant at any point on the scale — a displacement equivalent to pointer width represents less than a 1/4% change in indication.

Built-in full range protection permits applying up to 350 V and 10 kHz on any range without damage. Even at 6 MHz voltages as large as 35 V can be applied to the four most sensitive ranges of the Model 303 — other ranges are fully protected to 350 V.

The Model 303 may be used in its METER +10 dB mode for increased sensitivity. Indications down to 100 μ V over a frequency range of 10 Hz to 1 MHz can be made.

An amplifier mode is also available for low-noise, hum-free preamplification of low level signals.

Because Model 303 is rugged, has built-in batteries, and has its signal ground isolated from case ground, it is ideally suited for portable operation or for the toughest assignments in systems where there are heavy ground currents or strong fields.

VARIATIONS OF BASIC MODEL 303

- | | |
|---------------------|--|
| Model 303 | Operates from rechargeable battery or line. |
| Model 303-01 | Operates from line only. |
| Model 303-50 | Operates from rechargeable battery or line. Model 1303 20 dB Probe supplied. |
| Model 303-51 | Operates from line only. Model 1303 20 dB Probe supplied. |

FEATURES

1. All-solid-state.
2. Selection of battery/line or line-only versions.
3. 30 hours on battery for 14 hours charging. Use while charging if desired.
4. Wide voltage and frequency range.
5. 10 M Ω input resistance.
6. Overload-protected for all ranges.
7. Signal ground isolated from case ground.
8. Versions available with Model 1303 Probe for low input capacitance.
9. 40 dB amplifier, 2 Hz - 6 MHz, adjustable in 10 dB steps. Low input noise makes it useful as a pre-amplifier.
10. Rugged, mirror-backed taut band indicating meter has 5-inch logarithmic voltage scales and linear decibel scale.
11. BNC coaxial input, convertible to 3/4 inch spaced binding posts by use of Model 618 Adapter.
12. Half-rack modular package. Can be mounted in Model 800 Rack Mounting Kit, without modification.



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SPECIFICATIONS

Specifications	Models 303 and 303-01 without Probe	Models 303-50 and 303-51 with Model 1303 Probe
Voltage Lowest indication in "Meter +10 dB" Mode dBV Range	300 μ V - 350 V (12 ranges) 100 μ V (10 Hz - 1 MHz) -70 to +50	3 mV - 1000 V (11 ranges) 1 mV (100 μ V without Probe) (10 Hz - 1 MHz) -50 to +60
Frequency 3 dB Bandwidth	2 Hz - 6 MHz 1 Hz - 10 MHz	
Accuracy % of Indication	1%, 30 Hz - 1 MHz 2%, 20 Hz - 2 MHz 3%, 10 Hz - 3 MHz 5%, 2 Hz - 10 Hz to 35 V, 5%, 3 MHz - 6 MHz 35 - 350 V, 10%, 3 MHz - 6 MHz	
Response	Average, calibrated in RMS of a sine wave	
Indicator	Taut-band. Five inch logarithmic voltage scales, 1 to 3.5 and 3 to 10. Linear decibel scale, 0 to 10 dB.	
Input	BNC coaxial, convertible to binding posts. Separate signal and case grounds for isolated or above-ground operations.	
Input Impedance	10 M Ω 15 - 25 pF	10 M Ω 7.5 pF (25 pF without probe)
AC Amplifier	Gain 40 dB \pm 0.5 dB, 2 Hz - 6 MHz. FS output 0.1 V. Source resistance 150 Ω . Input noise < 30 μ V.	
Power Requirements Battery Use/Charge	Models 303 and 303-50, Rechargeable Battery/Line Models 303-01 and 303-51, Line Only, 120/240 V, 50-420 Hz, 3 W 30 hours use for 14 hours charge	
Color	Light gray panel, charcoal gray case	
Dimensions	6.1 H x 7.8 W x 10.2 D inches. (15,5 H x 19,8 W x 25,9 D cm)	
Weight	Models 303 and 303-50: 8 lbs (3,6 kg) net, 12 lbs (5,4 kg) shipping Models 303-01 and 303-51: 7 lbs (3,2 kg) net, 11 lbs (5,0 kg) shipping	
Optional Accessories	Model 1301 10 kV Probe Model 600 Resistors for current measurements from 10 μ A to 10 A	Model 1301 without 1303 Probe Model 600 without 1303 Probe Model 6314 Adapter to convert 1303 Probe to N/BNC
Rack-Mounting	Model 800 Rack Mounting Kit will accommodate 1 or 2 Model 303 (or other BL half-rack instruments) for 19 inch rack maunting without modification.	



Model 303-50 Rechargeable Battery/Line version,
with Model 1303 Probe



Model 303-01 Line-Powered version
mounted in Model 800 Rack



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PEAK RESPONDING VOLTMETER, MODEL 305A

Volts: 1 mV to 1,000 volts

Frequency: 5 cps to 500,000 cps

Pulses: 0.5 μ sec to 2.5 msec

GENERAL

Model 305A Peak Voltmeter measures PEAK or PEAK-to-PEAK value of any repetitive waveform — distorted or undistorted sinewaves, or pulses. Its operating mode can be selected to respond to a peak to peak and positive or negative peak of the waveform. The dc component of the waveform is not measured by the instrument.

The frequency range of the voltmeter when measuring sinewaves extends from 5 cps to 500 kc, however, distorted waveforms with harmonics extending up to 2 Mc could be measured. Pulses with duration from 0.5 microseconds to 5 milliseconds can be measured.

The instrument is designed for measurement of repetitive waveforms. The minimum repetition rate is 5 pps. For short pulses (below 1 μ sec) with a repetition rate lower than 100 pps, a correction should be applied to the indication as described in the instruction book for the instrument.

The indication of the instrument is displayed on a 5 inch mirror scale suppressed zero indication meter, which has shaped pole pieces so that a logarithmic response over 3 to 1 voltage range is achieved. This permits the same precision and same accuracy of reading at any part of the meter scale. The accuracy of the voltmeter is 2% to 5% depending on the waveform measured. The precision of the reading is better than 0.5% at any part of the scale.

The Model 305A Voltmeter can be used over its frequency range as a wideband amplifier with a gain of 86 db and a source impedance of approximately 3 ohms in series with 0.22 μ F. The maximum output voltage from the amplifier is 150 volts pp. The amplifier output is intended to be used for waveform monitoring only into loads above 30,000 ohms and below 10 pF. The amplifier output is not usable when taking voltage readings with the indicating meter.

Three controls are available from the front of the panel which allows realization of the maximum accuracy of the instrument for all kinds of waveforms.

The instrument is designed to be used with a 60 cps, 115 or 230 volts ac power supply.

CIRCUIT DESCRIPTION

The instrument consists of a compensated input attenuator, an input amplifier with a split phase output, a midsection attenuator, an output amplifier and a peak detector circuit.

The amplifiers and attenuators are designed with essentially flat frequency response over the specified fre-



quency range and with controlled fall-off characteristics above the highest frequency to avoid overshoot when fast risetime pulses are amplified.

Between the amplifiers a phase reversal stage is provided which, in case of unsymmetrical waveform, allows it to supply the output amplifier with more positive going waveform to avoid the cut-off of the output cathode follower. This switch should always be used when unsymmetrical waveforms are measured, even when peak-to-peak measurements are taken. Both amplifiers are stabilized with approximately 40 db of feedback to guarantee long and stable operation.

The output amplifier feeds a two stage peak detector-pulse stretcher circuit. The first stage of the detector circuit has a very short charging time constant, of the order of 0.01 μ sec. The output amplifier can charge this circuit to peak value of the waveform in 0.2 μ sec. Because of the longer discharge time constant of approximately 1 msec, the charge decays slowly which allows the second stage of the peak detector to be charged to the peak value of the waveform. The second stage of the detector has a discharging time constant of approximately 3.3 seconds so that the charge stays practically



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constant over the lowest repetition rate of waveform. For fast discharging and rapid successive measurement a discharge switch is provided on the front panel. The indicating meter measures the voltage on the second detector which is proportional to the peak value of the waveform.

For peak to peak measurement two channels of peak detection are provided, one responding to the positive, the other to the negative excursion of the waveform. For peak measurement only the positive responding channel is operative. When the negative peak has to be measured, the phase of the waveform should be reversed

SPECIFICATIONS – MODEL 305A

- Response:** Peak to Peak, Positive Peak or Negative Peak.
Voltage Range: 1 millivolt to 1,000 volts Peak. Signals below 1 mV can be measured by using the PEAK ADJ. Control.
Frequency Range: Sinewaves—5 cps to 500,000 cps. Distorted waveforms with harmonics up to 2 megacycles.
Waveforms: Pulses—0.5 microsecond to 2.5 milliseconds. Square Waves—200 cps or higher, or down to 50 cps with correction chart.
Accuracy:
- | | |
|----------------------------------|-----|
| Sine Waves | |
| 20 cps to 200 kc | ±2% |
| 5 cps to 20 cps and | |
| 200 kc to 500 kc | ±4% |
| Pulses | |
| — above 3 μsec and above 100 pps | ±3% |
| — above 1 μsec and above 100 pps | ±5% |
| — above 0.5 μsec and above 5 pps | ±5% |
| (using correction) | |
| Square Waves | |
| 200 cps or higher | ±3% |
| 50 cps to 200 cps | ±3% |
| (using correction) | |
- NOTE: On the 3.5 mV range, all measurements ±5%

in the second amplifier by setting the phase reversal switch to NEGATIVE.

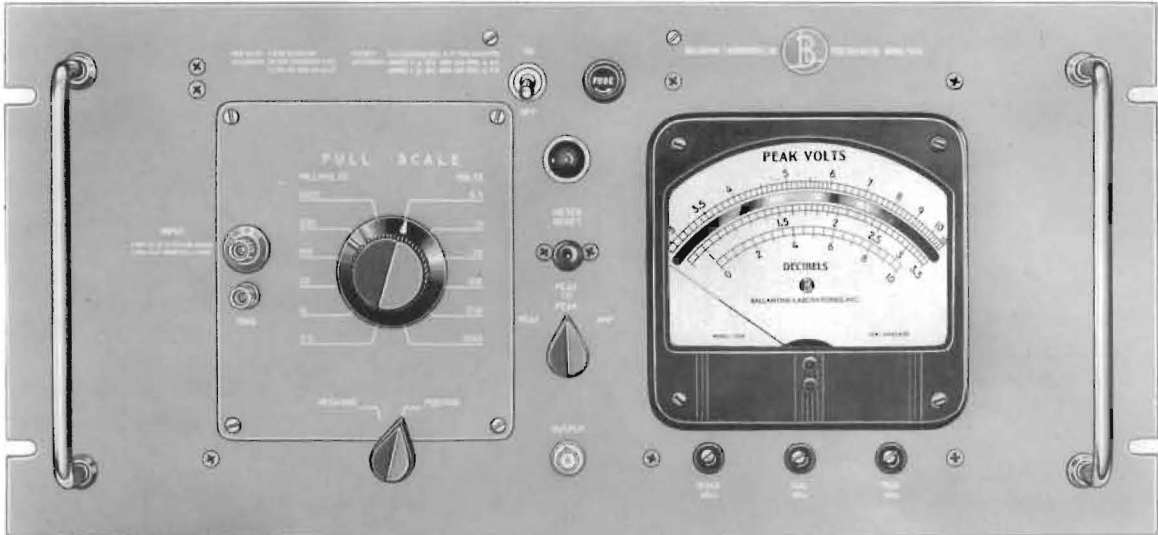
Three screwdriver adjustments are provided to control the linearity of the detector circuit on the bottom of the scale for various waveforms or to check the calibration of the instrument. Peak control also allows the measurement of peak values below 1 mV.

The instrument has an electronically regulated power supply with a Sola regulated transformer. Such power supply gives excellent regulation, which practically suppresses all the line transients. It also provides constant filament voltage and eliminates drift in the peak detector circuit and guarantees long life of the tubes.

- Input Impedance:** 3.5 mV to 100 mV (4 ranges)—2 megohms shunted by 25 pF. All other ranges—2 megohms shunted by 10 pF.
- Indicating Meter:** 5 inch mirror scale meter. Two voltage scales, 3 to 10 and 1 to 3.5 Linear 10 db decibel scale.
- Stability:** Variation of line voltage from 105 volts to 125 volts—no effect. Drift after 15 minute warm up — less than 0.2%.
- Amplifier:** Max gain 86 db adjustable in 10 db steps; Max output 70 V positive, 40 V negative; Response ±3%, 5 cps to 500 kc, for loads > 1 MΩ and < 10 pF; Source Impedance 3 Ω in series with 0.22 μF.
- Power Supply:** 115/230 volts, 82 watts, 60 cps.
50 cps can be supplied on special order.
- Standard Finish:** Panel smooth gray, box black wrinkle.
- Dimensions (inches) Portable:** 15 high x 8 wide x 10 deep. Rack: 8¾ high, 19 wide, 8¾ deep.
- Weight:** (pounds) Portable or rack — 21.
- Shipping Weight:** (pounds) Portable — 27; rack 40.

SPECIAL VERSION OF THE MODEL 305A

The Model 305A Voltmeter can be supplied for relay rack panel mounting (19"x8¾"). This version in gray is Model 305A-S/2. Special paint finishes can be supplied on relay rack panels to meet customer requirements at a slight increase in cost.



Typical Rack Version, Model 305A-S/2

SENSITIVE VIDEO

ELECTRONIC VOLTMETER - MODEL 310B

Voltage: 100 microvolts to 100 volts
(30 microvolts in DETECTOR mode, and up to 1,000 or to 10,000 volts with optional accessories)

Frequency: 10 cps to 6 Mc
(3 db bandwidth is 2 cps to 10 Mc)

FEATURES

- **2% ACCURACY** of reading over the entire scale—more accurate over lower-half of the scale than a linear meter rated 1% of full scale.
- **3000 HOURS** between calibration checks because of conservative operation of tubes and other components and large amounts of negative feedback.
- **100 μ V SENSITIVITY** and 6 Mc frequency range for the widest applications.

GENERAL DESCRIPTION

The Model 310B Video Voltmeter is a general purpose instrument for use over an extremely wide range of both voltage and frequency. It is a product-improvement version of the popular Model 310A into which has been incorporated (1) a wider frequency range (2) a larger indicating meter (3) greater accuracy, (4) increased feedback and longer life, (5) greater sensitivity, (6) provision for choice of co-axial or binding post input, and (7) improved serviceability.

Model 310B has a high impedance input attenuator followed by an amplifier and a meter-rectifier circuit. It is an average-responding instrument calibrated in rms of a sine wave.

Special design attention has been given to provide a long life within specifications over the entire frequency range. Tubes and other components are operated conservatively, and a high level of feedback is used over the entire band to make this long life possible. Tubes may be replaced without the necessity of an extensive alignment and calibration procedure.

In addition to its function as a voltmeter, Model 310B may be used as a stable amplifier with *up to 60 db over a range of 10 cps to 6 Mc, and with an input noise level of less than 25 μ V.*

The 3 db bandwidth of 2 cps to 10 Mc will be of value to those interested in measurements outside the calibrated, guaranteed frequency range of 10 cps to 6 Mc. A typical frequency response curve is shown in Figure 1.

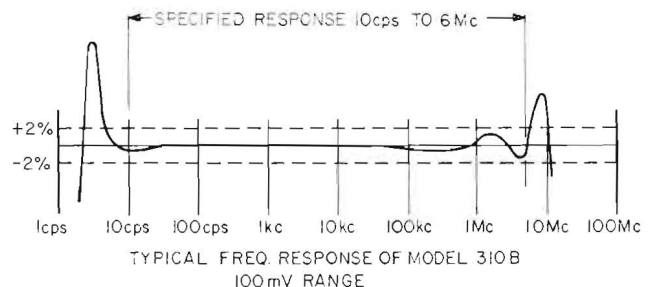


Figure 1—Typical Frequency Response of Model 310B



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Special Indicating Meters: Customers who require special meter scales having the db scale above the voltage scale, or having the db scale referenced to one milliwatt into 600 ohms, should request a special quotation.

Accessories (Optional)

Model 1310A Multiplier (plugs into input terminals of 310B) for measurements up to 1,000 volts

Model 1310B Multiplier (plugs into input terminals of 310B) for measurements up to 10,000 volts

Model 1311 High Voltage Probe, whose 3 foot cable connects into co-axial receptacle, for measurements of voltages up to 10,000 volts rms

Model 600 Series Precision Shunt Resistors (plugs into input terminals of 310B), having values from 0.01 ohm to 1000 ohms in decade steps, for measurements of currents from 0.1 microamperes to 10 amperes.

Rack Versions: The standard 19-inch relay rack version is called 310B-S/2. The instrument is the same as the 310B except that it is assembled on a 19-inch wide panel, 7 inches high. The depth is approximately 8½ inches. Standard color is gray. Ballantine will quote on other colors to customer specifications.

SPECIFICATIONS

Voltage Range: 100 μ V to 100 V. 30 μ V sensitivity in null DETECTOR mode. Accessories available to extend voltage range to 1000 V or to 10,000 volts rms.

Frequency Range: 10 cps to 6 Mc.

Decibel Range: -80 db to +40 db.

Accuracy: at any point on scale, any voltage. Error does not exceed 2%, 20 cps to 2 Mc; 3%, 10 cps to 4 Mc; 5%, 10 cps to 6 Mc.

Null Detector Mode: Sensitivity increases 10 db. Frequency range 10 cps to 6 Mc. Minimum indicated voltage 30 μ V.

Scales: Logarithmic voltage scale, 0.9 to 11. One linear db scale, 0 to 20. A mirror is located between the two scales for precise readings.

Input Impedance: 1 mV and 10 mV range—2 M Ω shunted by 25 pF. All other ranges—2M Ω shunted by 15 pF.

Characteristics of Amplifier: Maximum gain 60 db. Max. undistorted output voltage 2 V. Source impedance 700 Ω . Frequency response (with resistive load) \pm 1 db, 10 cps to 6 Mc. Equivalent

input noise: Input shorted, below 20 μ V for 60 db gain. Input open, below 25 μ V.

Signal Rectification: Average-responding. Instrument calibrated in rms of a sine wave.

Stability: For line voltage change of 10% from 115/230 V, variation is less than 1/5 of the stated accuracy.

Warmup time: Usable after 20 seconds under normal laboratory conditions. Reading is within ½% of final value in 10 minutes.

Power supply: 115/230 V, 50 to 400 cps, 40 watts.

Color: Portable, gray panel with black case. Rack, gray or special to customer's specifications.

Size (inches): Portable, 13 high x 7½ wide x 9½ deep. Rack, 7 high x 19 wide x 8½ deep.

Weight: Portable or rack, instrument alone, 14 pounds.

Shipping Weight: Portable, 20 pounds.
Rack, 32 pounds.



Relay Rack Version, Model 310B-S2



BALLANTINE LABORATORIES - BOONTON - N. J.

Printed in U.S.A.

10-56-Y-5

SENSITIVE VIDEO

ELECTRONIC VOLTMETER - MODEL 314A

Replaces Model 314

Voltage: 100 microvolts to 100 volts
without probe
1 millivolt to 1000 volts with
probe
(30 microvolts in DETECTOR
mode, and up to 10,000 volts with
optional accessories)

Frequency: 10 cps to 6 Mc
(3 db bandwidth is 2 cps to 10 Mc)

FEATURES

- **2% ACCURACY** of reading over the entire scale—more accurate over lower-half of the scale than a linear meter rated 1% of full scale.
- **3000 HOURS** between calibration checks because of conservative operation of tubes and other components and large amounts of negative feedback.
- **100 μ V SENSITIVITY** and 6 Mc frequency range for the widest applications.

GENERAL DESCRIPTION

The Model 314A Video Voltmeter is a general purpose instrument for use over an extremely wide range of both voltage and frequency. It is a product-improvement version of the popular Model 314 into which has been incorporated (1) a wider frequency range, (2) a larger indicating meter, (3) greater accuracy, (4) increased feedback and longer life, (5) greater sensitivity, (6) improved serviceability.

Model 314A is supplied with the Model 5314 Probe. When this probe is used, it presents an input impedance of 10 megohms shunted by 7.5 pF, and introduces 20 db attenuation between its input and the co-axial input terminal of the voltmeter. The voltage range, using this probe, is 1 mV to 1000 V. Measurements may be made over the range of 100 microvolts to 100 volts without the probe.

The large indicating meter, with its 5 inch logarithmic voltage scale, makes it possible to measure with the same accuracy and precision at full scale or at the very bottom of the scale.

Model 314A has a high impedance input attenuator followed by an amplifier and a meter-rectifier circuit. It is an average-responding instrument calibrated in rms of a sine wave.

Special design attention has been given to provide a long life within specifications over the entire frequency range. Tubes and other components are operated conservatively, and a high level of feedback is used over



Model 314A Voltmeter with Model 5314 Probe and Model 617 Adapter (co-axial to binding post).

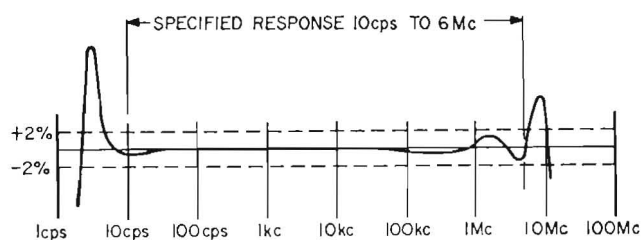


Figure 1—Typical Frequency Response of Model 314A



BALLANTINE LABORATORIES - BOONTON - N. J.

the entire band to make this long life possible. Tubes may be replaced without the necessity of an extensive alignment and calibration procedure.

In addition to its function as a voltmeter, Model 314A may be used as a stable amplifier with *up to 60 db gain over a range of 10 cps to 6 Mc, and with an input noise level of less than 25 μ V.*

The 3 db bandwidth of 2 cps to 10 Mc will be of value to those interested in measurements outside the calibrated, guaranteed frequency range of 10 cps to 6 Mc. A typical frequency response curve is shown in Figure 1.

Special Indicating Meters: Customers who required special meter scales having the db scale above the voltage scale, or having the db scale referenced to one milliwatt into 600 ohms, should request a special quotation.

SPECIFICATIONS

Voltage Range: 100 μ V to 100 V without probe, and 1 mV to 1000 V with probe. 30 μ V sensitivity in null DETECTOR mode. Accessories available to extend voltage range to 10,000 volts rms.

Frequency Range: 10 cps to 6 Mc.

Decibel Range: -80 db to +40 db.

Accuracy: *at any point on scale, any voltage.* Error does not exceed, 2%, 20 cps to 2 Mc; 3%, 10 cps to 4 Mc; 5%, 10 cps to 6 Mc.

Null Detector Mode: Sensitivity increases 10 db. Frequency range 10 cps to 6 Mc. Minimum indicated voltage 30 μ V.

Scales: Logarithmic voltage scale, 0.9 to 11. One linear db scale, 0 to 20. A mirror is located between the two scales for precise readings.

Input Impedance: 10 M Ω shunted by 7.5 pF with probe and 2 M Ω shunted by 15 or 25 pF without probe.

Characteristics of Amplifier: Maximum gain 60 db. Max. undistorted output voltage 2 V. Source impedance 700 Ω . Frequency

Accessories (Optional)

Model 1314 Multiplier (plugs into input terminals of 314A) for measurements up to 10,000 volts rms.

Model 1311 High Voltage Probe (whose 3 foot cable connects into co-axial receptacle), for measurements up to 10,000 volts rms.

Model 600 Series Precision Shunt Resistors (plugs into input terminals of 314A), having values from 0.01 ohm to 1000 ohms in decade steps, for measurements of currents from 0.1 microampere to 10 amperes.

Rack Versions: The standard 19-inch relay rack version is called 314A-S/2. The instrument is the same as the 314A except that it is assembled on a 19-inch wide panel, 7 inches high. The depth is approximately 8½ inches. Standard color is gray. Ballantine will quote on other colors to customer specifications.

response (with resistive load) \pm 1 db, 10 cps to 6 Mc. Equivalent input noise: Input shorted, below 20 μ V for 60 db gain. Input open, below 25 μ V.

Signal Rectification: Average-responding. Instrument calibrated in rms of a sine wave.

Stability: For line voltage change of 10% from 115/230 V, variation is less than 1/5 of the stated accuracy.

Warmup time: Usable after 20 seconds under normal laboratory conditions. Reading is within ½% of final value in 10 minutes.

Power supply: 115/230 V, 50 to 400 cps, 40 watts.

Color: Portable, gray panel with black case. Rack, gray or special to customer's specifications.

Size (inches): Portable, 13 high x 7½ wide x 9½ deep. Rack, 7 high x 19 wide x 8½ deep.

Weight: Portable or rack, instrument alone, 13 pounds.

Shipping Weight: Portable 20 pounds, Rack 32 pounds.

SPECIAL VERSIONS OF THE MODEL 314A

A number of special versions have been designed to meet customers' particular requirements. The modifications are such as to have general appeal and are listed in the following table. Other variations, including dif-

ferent finishes, to suit a customer's preferences can be furnished with only a nominal increase in price and delivery time.

Model No.	Brief Description of Special Version
314A-S/1	Electrically similar to basic Model 314A but has decibel scale referred to 1 mW in 600 ohms (0.775 volts).
314A-S/2	Electrically similar to basic Model 314A but mounted on a 19" x 7" x 1/8" relay rack panel. Overall depth from rear of panel 8½".
314A-S/3	Electrically similar to basic Model 314A-S/2 but has special db scale having 0 db referred to 1 mW in 600 ohms (0.775 volts).

FEDERAL STOCK NUMBER

Purchased by U. S. Government agencies under Federal Stock Number 6625-788-0919



BALLANTINE LABORATORIES - BOONTON - N. J.

PEAK-TO-PEAK INFRASONIC* VOLTMETER MODEL 316

Volts: 0.02 volt to 200 volts, peak-to-peak
Frequency: 0.01 cps to 30,000 cps
Full specifications below

GENERAL

The Model 316 has been made available to satisfy the need for reliable voltage measuring apparatus in such applications as the development, design and routine testing of automatic control systems involving low frequency servomechanisms, and in many other fields where sub-audio frequencies down to 0.01 cps are encountered. An instance of its utility is in monitoring the outputs of a number of commercially available, low-frequency signal generators which are not furnished with an output meter.

A feature of the Model 316 is that it is almost completely free of meter pointer "flutter" down to 0.05 cps, while down to 0.01 cps the variation will be small compared to the sweep occurring when using a dc voltmeter to observe the peak amplitude of infrasonic waves. Power line transients have negligible effect on the meter reading. The voltmeter is direct reading in the frequency band 0.05 to 30,000 cps, and a correction curve is provided for the range 0.01 to 0.05 cps.

DESCRIPTION

Following the basic pattern of other well-established Ballantine voltmeters the design of the Model 316 involves an input attenuator followed by a wide-band amplifier, a full-wave detector and a logarithmic metering system. The attenuator is frequency compensated and has four decimal steps which in association with other features of the instrument allow it to cover a range of 20 millivolts to 200 volts peak-to-peak with an accuracy of 3% at any reading and for all frequencies in the range 0.05 to 30,000 cps. An input resistance of 10 megohms is maintained on all ranges together with a shunt capacitance between 17 and 40 pF depending on the combination of control settings adopted. Substantial inverse feed-back and premium tubes are incorporated in the wide-band amplifier which is of a special form to be free from zero drift and yet to provide for a flat frequency response down to 0.05 cps without recourse to impractically large coupling capacitors.

A carefully planned switching system associated with the input attenuator permits the user to expeditiously correct the effects of severe overload and of the application of waves having a large dc component, in addition to allowing him to rapidly reset the meter following a

*As defined in I.R.E. "Standards on Electroacoustics, 1951"



reduction or disconnection of the voltage being measured. The reset function is achieved by discharging peak-responding "memory" circuits associated with a full-wave signal rectifier which activates a differential cathode-follower stage feeding a logarithmic meter. A power transformer of the constant voltage type completely immunizes the voltmeter from wide variations in line voltage as well as eradicating the effects of line transients which could otherwise be injected into the instrument and produce spurious readings.

AVAILABLE ACCESSORIES

For measurements above 200 volts peak-to-peak and up to a limit of 20,000 volts peak-to-peak of symmetrical waves the Ballantine Model 1316 Multiplier is recommended as an accessory for the Model 316. When ordering the Model 1316 for this purpose the application should be specified so that matching adjustments may be effected on it at the factory to suit the Model 316.



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SPECIFICATIONS — MODEL 316

Voltage Range: 20 millivolts to 200 volts peak-to-peak in four decade ranges, 0.2, 2, 20, and 200 volts full scale. (Not responsive to a steady dc component of measured signal but will withstand up to 200 volts dc.)

Frequency Range: 0.05 cps to 30 kc for signals having approximately sinusoidal waveform. Correction chart supplied for range 0.01 to 0.05 cps. Square waves measured with stated accuracy down to 0.5 cps.

Accuracy: 3% over entire range regardless of meter scale position.

Input Impedance: 10 megohms in shunt with 17 pF min or 40 pF max, depending on control settings.

Stability: No change in reading over the entire range resulting from line variation from 100 to 130 volts.

Scales: Logarithmic voltage scale (illuminated) reading from 2 to 20; auxiliary linear decibel scale reading from 0-20 db.

Power Supply: 100-130 volts, 60 cps, 45 watts. Note that the instrument will not operate satisfactorily on line frequencies other than the nominal 60 cps. On special order we can supply an instrument to operate on 230 volts and 50 cycles.

Standard Finish: Panel black crackle, box black wrinkle.

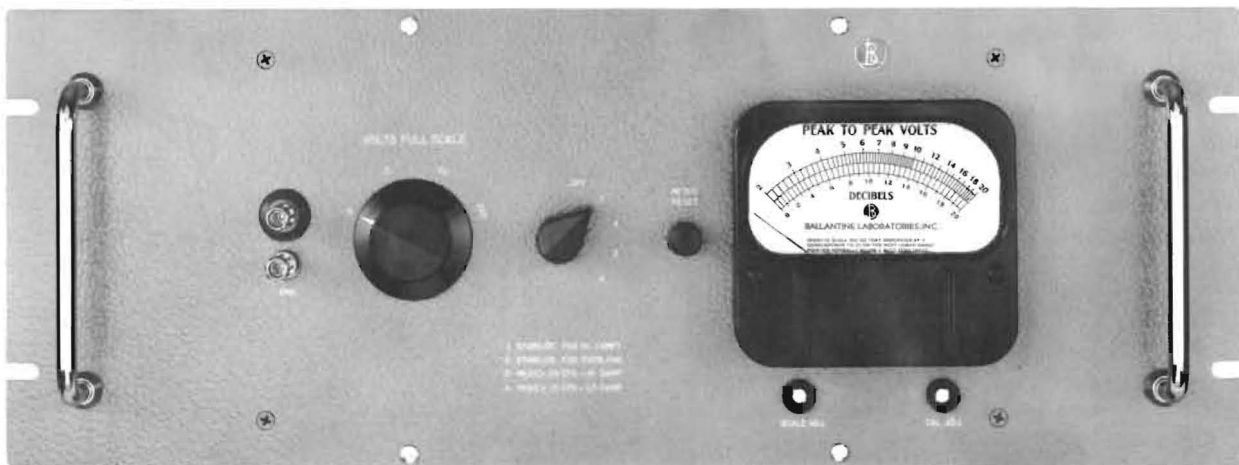
Dimensions: 7½" high, 6⅞" wide, 12⅝" long. Special version Model 316S/2 mounted on relay rack panel 19" x 7" x ⅛" thick; overall depth from rear of panel is 6⅓".

Weight: Portable 14 pounds; Rack 15 pounds.

Shipping Weight: Portable 19 pounds; Rack 28 pounds.

SPECIAL VERSION OF THE MODEL 316

The Model 316 Voltmeter can be supplied for relay rack panel mounting (19"x7") as illustrated below. This version in gray is the Model 316-S/2. Special paint finishes can also be supplied on the relay rack panels to meet customer requirements. If customer's paint specification is unusual or hard to obtain or to match, it is suggested that the customer supply a one pint can of the paint to save both time and cost.



Relay Rack Version, Model 316-S/2



Printed in U.S.A.

BALLANTINE LABORATORIES - BOONTON - N. J.

11-64-Y-7

SENSITIVE, WIDEBAND

ELECTRONIC VOLTMETER MODEL 317

VOLTAGE RANGE: 300 μ V to 350 V
(As null detector to 100 μ V)

FREQUENCY RANGE: 10 Hz to 11 MHz
(As null detector, 5 Hz to 30 MHz)

FEATURES

- Over a million to one range in frequency
- Over a million to one range in voltage
- Five inch logarithmic voltage scales, each with uniformly high accuracy and exceptionally high resolution over its entire length
- As a null detector the maximum sensitivity is 100 μ V from 10 Hz to 20 MHz, and approximately 600 μ V at 30 MHz
- Stable, low distortion 60 db amplifier, flat to ± 1 db from 6 Hz to 11 MHz
- As much as 50 db multi-loop feedback in each of the two amplifiers contributes markedly to the accuracy and long-term stability
- Frame grid instrument-type tubes, operated conservatively, are used in critical circuits
- Co-axial input reduces possible errors caused by ground current. Binding post adapter is supplied for use at low frequencies or when a co-axial cable or cathode follower probe is not required
- The Cathode Follower Probe Model 2317A contains a rugged RCA Nuvistor tube near its tip. Measurements may be made up to 300 mV with the 2317A Probe. A 60 db Attenuator Adapter Model 3317 is required for measurements from 300 mV to 350 V
- Instrument is average-responding, with or without the probe, calibrated in rms of a sine wave
- The case may be tilted when required, by use of a bail. The frame around the front of the instrument is designed to protect the meter and controls during servicing, and in shipment
- Model 317 is available in portable or 19 inch rack versions

OPTIONAL ACCESSORIES ARE:

1. Model 3317 60 db Attenuator Adapter for attachment to Model 2317A Probe for measurements from 300 mV to 350 V
2. Model 1311 High Voltage Probe for measurements up to 10,000 volts
3. Model 6314 BNC Adapter to connect Model 2317A probe, with or without 3317 Adapter, to BNC connector
4. Series 600 Precision Shunt Resistors in decade steps from 0.01 ohm to 1000 ohms for connection to Model 317 binding post input for measurement of current directly on voltmeter



Model 317
with Model 2317A Cathode Follower Probe



Model 3317
60 db Adapter



Model 6314
BNC Adapter



Model 1311
High Voltage Probe

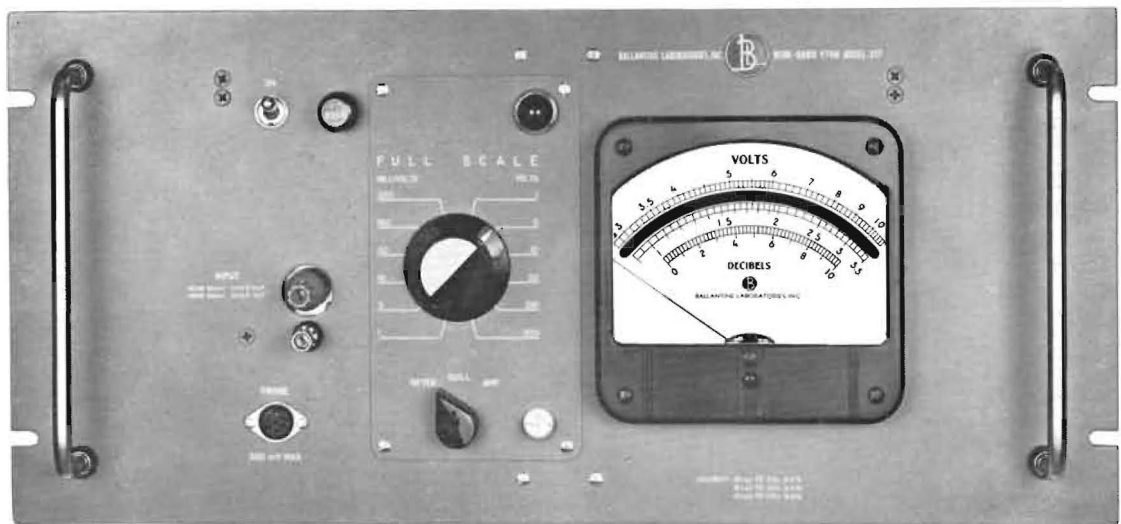


Model 600
Precision Shunt
Resistor (typical)

BALLANTINE LABORATORIES - BOONTON - N. J.

SPECIFICATIONS:

Voltage range	300 μ V to 350 V (As null detector to 100 μ V)	Amplifier	Maximum gain 60 db \pm 1 db from 6 Hz to 11 MHz; max. output voltage 2.5 from source impedance of 450 Ω ; noise at 60 db gain, less than 45 μ V input open, and less than 35 μ V input shorted
Frequency range	10 Hz to 11 MHz (As null detector 5 Hz to 30 MHz)	Indication	Average-responding, calibrated in rms of sine wave
Decibel range	-70 db to +50 db, referred to 1 V	Stability	Line voltage of 115/230 V \pm 10/20 V results in change of less than 1/10 of stated accuracy
Accuracy	Basic instrument, in percent of reading at any point on scale, any voltage: 2%, 20 Hz to 2 MHz; 3%, 10 Hz to 6 MHz; 5%, 10 Hz to 11 MHz With 2317A Probe, add \pm 0.5%, 10 Hz to 2 MHz; \pm 2%, 60 Hz to 11 MHz	Warmup time	20 seconds, within 1/2% of final reading in 2 minutes
Scales	Logarithmic voltage 1 to 3 and 3 to 10, each with 10% overlap at both ends Mirror is between voltage scales. db scale is linear, 0 to 10	Power supply	115/230 V, 50 to 420 Hz, 70 W
Input impedance	With 2317A probe, 10 M Ω shunted by 7 pF; with 3317 60 db Adapter > 1000 M Ω shunted by < 4 pF Without probe, 2 M Ω shunted by 24 pF on ranges up to 300 mV and shunted by 11 pF on ranges above 300 mV	Color	Portable, gray panel and black case; rack, gray standard, or to customer's specification at slight increase in cost
		Size (inches)	Portable, 13 H x 7-1/2 W x 9-1/2 D; rack, 8-1/2 H x 19 W x 8-1/2 D
		Weight (pounds)	Portable or rack, 17; shipping weight, 23 for portable and 32 for rack



Model 317-S2 Relay Rack Version
with Model 2317A Cathode Follower Probe

Ordering instructions Model 2317A Cathode Follower Probe is normally supplied with Model 317 unless specified otherwise. If the Model 3317 60 db Adapter is required for probe measurements from 300 mV to 350 V, it should be specifically added to the order.

Federal stock number Purchased by U. S. Government agencies under Federal Stock Number 6625-077-2959.



BALLANTINE LABORATORIES - BOONTON - N. J.

SENSITIVE **TRUE-RMS** ELECTRONIC VOLTMETER — MODEL 320A

- **FOR ACCURATE MEASUREMENTS ON A WIDE RANGE OF WAVEFORMS**
- **5 cps — 4 Mc**
(3 db bandwidth, 2 cps — 7 Mc)
- **100 μ V — 330 V**
(to 10 μ V as **NULL DETECTOR**)
- **CREST FACTOR UP TO 15**
- **NO THERMOCOUPLES. USES TIME-PROVEN DIODE MATRIX TO PRODUCE SQUARE LAW RESPONSE**



The Ballantine Model 320A is a sensitive wide band TRUE ROOT MEAN SQUARE voltmeter.

Its main characteristics — accuracy, bandwidth, and maximum crest factor — are chosen so that the instrument is suitable for accurate measurement of a wide variety of complex waveforms which are encountered in acoustical, vibrational, noise, pulse and magnetic measurements. Besides sine waves, it measures distorted waveforms that include random noise and pulse trains with duty cycles as low as 0.04 and pulse widths as short as 0.3 μ sec.

The true-rms response in the Model 320A is achieved by means of the Ballantine patented square law detector which is an accurate, wideband, segmented function generator. In conjunction with a full wave rectifier, this detector provides a wide dynamic range with instantaneous squaring action, unaffected by the normal range of ambient temperature, overload, or component aging. Thermocouples are not used. The indication is achieved on two five-inch mirror-backed logarithmic scales. The same precision and accuracy applies to measurements at any point on the scales. An associated linear db scale with one volt as zero reference is supplied with the standard instrument.

Special design consideration has been given to operation under disturbing interferences. The coaxial type UHF input terminal provides a low ground impedance input which reduces the error due to ground currents, and provides for coaxial input for accurate high frequency measurements. A Model 617 adapter, supplied with the voltmeter, may be used to convert the coaxial input to standard $\frac{3}{4}$ " spacing binding posts, sometimes preferred for low frequency high-level measurements. The warm-up drift is kept small so that the voltmeter is usable within 20 seconds after being turned on. The effect of line voltage transients is minimized so that the Model 320A may be used under very unfavorable power line conditions.



MODEL 320A

Besides the excellent initial performance, great emphasis is placed on reliability and long life. Because of the conservative loading of tubes and components, proper amount of feedback, and the reserve in accuracy specifications, it is expected that the great majority of voltmeters will meet their specifications over 5,000 hours of normal use without the need for readjustments or recalibration. The design is such that whenever a tube is changed it does not influence the performance over most of the useful band, and does not require recalibration or adjustment.

OTHER USES of Model 320A

In addition to its use as a voltmeter it may be used (1) as a null indicator to 10 microvolts (2) as a broadband amplifier with floating, grounded, or symmetrical output (3) as an ammeter from 0.1 microampere to 10 milliamperes with the aid of Model 600 Resistors (4) as

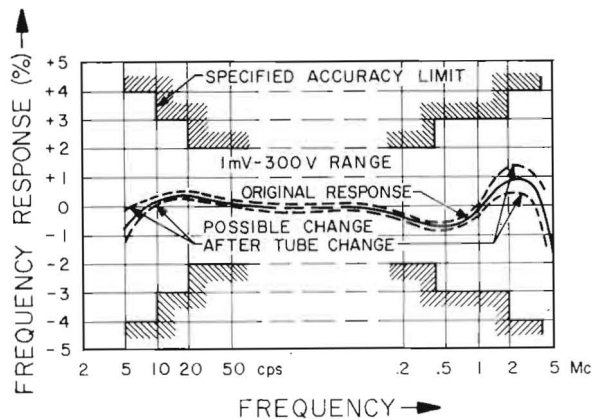


BALLANTINE LABORATORIES - BOONTON - N. J.

a wattmeter up to 1 watt with Model 600 Resistors, or (5) to measure true-rms voltages up to 10,000 volts using Model 1311 or 1320 "multipliers."



19 inch Relay Rack Version Model 320A-S2



Effect on frequency response resulting from replacement of all amplifier tubes with ones having 15% lower $G_{m\mu}$. This is equivalent to at least 5000 hours of use.

SPECIFICATIONS

- Voltage Range** — 100 μ V to 330 V in 13 ranges
10 μ V to 100 μ V as null detector
- Frequency Range** — 5 cps to 4 Mc
(2 cps to 7 Mc for 3 db bandwidth)
- Waveforms** — Sine, distorted sine, complex, pulse, or random
- Max Crest Factor** — 15 down scale
5 full scale
- Accuracy at ANY Point on the Scale**
Sine, complex, and random waveforms
For voltages above 0.3 mV
20 cps to 400 kc 2% of indication
10 cps to 2 Mc 3% of indication
5 cps to 4 Mc 4% of indication
For voltages from 0.1 mV to 0.3 mV
10 cps to 2 Mc 4%
5 cps to 4 Mc 5% at full scale
7% at down scale
- Pulse trains and flat top waveforms**
Crest factor below 4 (FS) to 10 (DS) as above
Crest factor below 5 (FS) to 15 (DS)
2% additional uncertainty
- Scales**
Voltage scales: 0.95 to 3.3, logarithmic
3.0 to 10.6, logarithmic
separated with mirror
DB scale: 0-10 db linear
- DB Range** — -80 to +40 db referred to 1 V
- Input Impedance**
30 mV to 300 V range, 10 M Ω parallel with 11 pF
0.3 mV to 10 mV range, 10 M Ω parallel with 27 pF
- Equivalent Input Noise**
Input shorted, 20 μ V max; input open, 40 μ V max

- Response Time**
Indicator 1 to 2 sec (higher values supplied on special order)
Mean square output 0.05 sec
- Warm-up Time** — Less than 0.3% drift after 15 min
- Ambient Temperature Effect**
Drift is less than 1/10 of stated accuracy 25°C \pm 5°C
- Stability**
Expected calibration stability 5000 operating hrs
Recommended calibration periods 1000 operating hrs
Effect of line voltage change Less than 1/10 stated accuracy for 115/230 V \pm 10%
- Amplifier Characteristics**
Output Binding posts in rear, balanced or single ended
Max gain 90 db
Max output 50 V into 20,000 ohms;
10 V into 2,000 ohms
Source impedance 350 ohms at 1 kc
Frequency response \pm 0.5 db from 5 cps to 2 Mc;
-1 db at 4 Mc
- Mean Square DC Output**
Max output -1.0 V (0.2 V corresponds to full scale deflection)
Source resistance 1,000 ohms
- Power Requirements** — 115/230 V, 50 to 420 cps, 90 W
- Dimensions (inches)** — Portable: 15 $\frac{1}{8}$ H x 8 $\frac{3}{8}$ W x 11 $\frac{1}{4}$ D
Rack: 8 $\frac{3}{4}$ H x 19 W x 12 $\frac{3}{4}$ D
- Weight (pounds)** — Portable or rack: 22
Shipping weight: 27 for portable, 40 for rack

FEDERAL STOCK NUMBER

Purchased by U. S. Government agencies under Federal Stock Number 6625-726-6949.



BALLANTINE LABORATORIES - BOONTON - N. J.

TRUE-RMS-AVERAGE-PEAK(R-A-P)

ELECTRONIC VOLTMETER — MODEL 321

- **THREE INSTRUMENTS IN ONE — MEASURES TRUE-RMS, AVERAGE, OR PEAK VOLTAGE**
- **MEASURES WIDE RANGE OF VOLTAGES, FREQUENCIES, AND WAVEFORMS**
- **SAME ACCURACY AND RESOLUTION OVER ENTIRE FIVE-INCH LOGARITHMIC SCALES**
- **ACCURACY OF 2% OF INDICATION IS FAR BETTER OVER THE LOWER HALF OF THE SCALE THAN FOR A LINEAR SCALE INSTRUMENT RATED AT 1% F.S.D.**

Model 321 is an electronic voltmeter designed for accurate measurements of the true-rms, average, or peak values of a wide range of voltages and waveforms. It is *not* limited to measurement of pure sine waves to obtain the specified accuracy, but will measure sine, distorted sine, complex, pulse, or random signals whose frequency components lie within the designated frequency range.

Five-inch logarithmic voltage scales make it possible to specify uniform resolution and accuracy in % of *indication* over the entire scale length. This feature is not possible with a linear scale meter.

Model 321 consists of a wideband amplifier, attenuator, and detector system having a high multi-loop feedback. True-rms response is achieved by means of the Ballantine patented square law detector which is a wideband, segmented function generator. In conjunction with a full wave rectifier, this detector provides an accurate, wide dynamic range having instantaneous squaring action. Its operation is unaffected by the normal range of ambient temperature, by overload, or by component aging. It has no low frequency limitation. The dc output of this detector is proportional to the mean square of the input signal voltage. The square root of this mean square value (the true-rms) is obtained by calibrating the meter in volts which are proportional to the square root of the current through the meter. This system has been in successful use in Ballantine true-rms instruments for over 10 years. No thermocouples are used. Average response is achieved by introducing an averaging circuit ahead of the function generator described above. This produces a true average; it is *not* the equivalent rms of a pure sine wave having that average value. Peak response is achieved by introducing a peak-responding circuit ahead of the function generator. This produces a reading which is that of the highest repetitive peak.



In addition to its use as a voltmeter, Model 321 may be used as a wideband 90 db amplifier. Binding posts on the rear provide for single-ended or balanced output.

A dc recorder may be connected to the "MEAN SQUARE" receptacle for recording measurements. The dc output is proportional to the mean square of the input signal.

In the "NULL DETECTOR" position of the function switch, signals as low as 10 microvolts may be measured.

A feature that is important for a wideband sensitive voltmeter is a coaxial input. Use of this feature is recommended over the optional binding post supplied with Model 321 whenever measurements are to be made below a few millivolts, or in areas where there may be strong interfering signals.

The 19 inch rack version, Model 321-S/2, is available in standard gray or will be supplied to your color specifications.



BALLANTINE LABORATORIES - BOONTON - N. J.

SPECIFICATIONS

	RMS (Indicates True-rms)	AVERAGE (Indicates Average)	PEAK (Indicates Highest Repetitive Peak)
Voltage Range	100 μ V — 330 V	300 μ V — 330 V	300 μ V — 330 V
As null detector	10 μ V — 100 μ V		
Frequency Range	5 cps — 4 Mc	10 cps — 1 Mc	10 cps — 1 Mc
3 db bandwidth	2 cps — 7 Mc		
Waveforms	Sine, distorted sine, complex, pulse, random	Sine, distorted sine, complex, pulse, random	Sine, distorted sine, repetitive pulses to 5 μ s, having min duty cycle of 0.007; square wave response 100 cps - 400 kc
Crest Factor	15 down scale, 5 up scale; for pulse and flat waveforms crest factor is 10 down scale, 4 up scale	7 down scale, 4 up scale	
Accuracy above 300 μ V	(See also Notes 1 and 2 below)		
20 cps - 0.4 Mc	2% of indication	2% of indication	3% f.s.d.
10 cps - 1. Mc	3% of indication	5% of indication	5% f.s.d.
10 cps - 2. Mc	3% of indication		
5 cps - 4. Mc	4% of indication		
Accuracy below 300 μ V			
20 cps - 0.4 Mc	3% of indication		
10 cps - 2. Mc	4% of indication		
5 cps - 4. Mc	10% of indication		
Expected Calibration Stability	5000 hours	5000 hours	1000 hours
Effect of Ambient Temperature, 20°C to 30°C	< 1/10 stated accuracy	< 1/10 stated accuracy	< 1/2 stated accuracy
Effect of Line Voltage Change	Change of 10% from nominal line voltage of 115/230 V affects stated accuracy by less than 1/10		
Input Impedance	10 M Ω parallel with 11 pF; 30 mV - 330 V; 10 M Ω parallel with 27 pF, 0.3 mV - 10 mV		
Equivalent Input Noise	Input shorted, 20 μ V max; input open, 40 μ V max		
Scales	Voltage 0.95 to 3.3 and 3.0 to 10.6, logarithmic; decibels, 0 - 10 linear		
Decibel Range	-80 to +40 db referred to 1 V		
Response Time	Indicator 1 to 2 s; mean square output 0.05 s		
Amplifier	Output on binding posts in rear, balanced or single-ended; max gain 90 db, adjustable in 10 db steps with range selector; intermediate values may be read on db scale; max output 50 V into 20,000 Ω ; 10 V into 2,000 Ω ; source impedance 350 Ω at 1 kc; frequency response \pm 0.5 db from 5 cps to 2 Mc, -1 db at 4 Mc, with 25 pF maximum capacitive loading.		
Mean Square DC	Output on front panel BNC receptacle; output is -0.2 V corresponding to full scale deflection; max output is -1.0 V; source resistance is 1,000 Ω		
Power Supply	115/230 V, 50 to 420 cps, 90 W		
Dimensions (inches)	Portable 15 $\frac{1}{8}$ H x 8 $\frac{1}{8}$ W x 11 $\frac{3}{4}$ D; Rack 8 $\frac{3}{4}$ H x 19 W x 12 $\frac{3}{4}$ D		
Weight (pounds)	Portable or rack, 22; shipping weight, portable 27 and rack 40		
Color	Portable, gray panel and black case; rack, gray or special to order		
Note 1	Midband accuracy of "2% indication" is far more accurate over the lower half of the scale than an instrument rated at "1% of full scale deflection (f.s.d.)".		
Note 2	Logarithmic voltage scales assure uniform accuracy as well as uniform resolution over their entire five inches. No linear scale indicator has this very important feature.		



Relay Rack Version
Model 321-S/2



BALLANTINE LABORATORIES - BOONTON - N. J.

WIDE BAND
ALL SOLID STATE

TRUE RMS

ELECTRONIC VOLTMETER - - MODEL 323

- 300 μ V - 330 V
- 10 Hz - 20 MHz
- OPERATION FROM RECHARGEABLE BATTERY OR LINE POWER
- LOGARITHMIC VOLTAGE SCALES FOR UNIFORMLY HIGH ACCURACY AND RESOLUTION FOR ALL READINGS

Model 323 Measures a Wide Range of Waveforms



DESCRIPTION

The Ballantine Model 323 measures TRUE ROOT MEAN SQUARE voltages from 300 microvolts to 330 volts in the frequency range of 10 Hz to 20 MHz for an exceptionally wide variety of waveforms. It is a rugged all-solid-state instrument which operates from built-in rechargeable batteries or from line power. One version, Model 323-01, is available for operation on line power only.

The indicating meter on Model 323 makes use of the well-known Ballantine feature of logarithmic voltage scales and linear decibel scale, the result of which is uniformly high accuracy and resolution over the full length of the scales. The Ballantine accuracy of "2%" means "2% of the actual indication" whether it is at the top or at the bottom of a scale. (A linear voltage scale meter has diminishing accuracy and resolution at the low end of the scale.)

Model 323 accurately measures the TRUE-RMS, or effective voltage, not only of sine waves but also of square waves, noise voltages, or pulses having duty cycles as low as 0.04. It must **not** be classified with voltmeters labelled RMS but which are overage or peak-responding, calibrated in RMS of a pure sine wave.

FEATURES

1. Operates from power line or from built-in rechargeable batteries.
2. Long operating life between charges.
3. Square low response from silicon backward diodes — no thermocouples used.
4. Silicon transistors.
5. Measures waveforms with high crest factors.
6. Overload-protected.
7. DC output, simultaneous with meter reading, for recorder applications.
8. Separate, isolated signal and case grounds.
9. BNC coaxial input, convertible to binding posts.
10. Rugged, mirror-backed tout bond indicating meter.
11. Indicator time constant as high as 30 seconds on special versions.
12. Optional 80 dB Attenuator Probe, Model 1301 for 1000 V and 10,000 V operation.
13. Optional Resistor Assemblies, Model 600, for measuring current.
14. Optional Rack Mounting Kit — Model 800 requires no modification of Model 323.



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SPECIFICATIONS

Voltage Range	300 μ V to 330 V, in 12 ranges
Sensitivity as Null Detector	70 μ V
Decibel Range	-70 dB to +50 dB, referred to 1 V
Frequency Range	10 Hz to 20 MHz (-3 dB, < 4 Hz and > 30 MHz)

Accuracy at All Points on Scale, All Ranges

Frequency	Voltage	Decibel
50 Hz to 10 MHz	2%	0.2 dB
20 Hz to 15 MHz	3%	0.3 dB
10 Hz to 20 Hz	5%	0.5 dB
15 MHz to 20 MHz	5% to 100 V 10% to 300 V	0.5 dB 1.0 dB

Response	True rms for wide range of waveforms including sine, distorted sine, complex, pulse, or random
Input Impedance	2 M Ω shunted at 15 pF except 25 pF, 1 mV to 30 mV
Crest Factor	5 at full scale to 14 down scale
Scales	Volts: 1 to 3 and 3 to 10 with overlap Decibels: 0 to 10
Power Requirements	
Model 323	105-135/210-270 V, 50 to 420 Hz, 6 W and internal rechargeable nickel-cadmium battery.
Model 323-01	105-135/210-270 V, 50 to 420 Hz, 6 W
Battery Use/Charge Time	20 hours use for 15 hours charge
Common Mode Rejection	DC > 120 dB; 1 kHz > 120 dB; 1 MHz > 80 dB
Equivalent Noise	Input shorted < 30 μ V; input open < 35 μ V
Response Time	2 sec up scale and 3 sec down scale in NORMAL mode

Maximum Continuous Overload	330 V at 1 kHz on all ranges; 600 V dc on all ranges
Overload Recovery, All Ranges	To return to 1% of final indication in NORMAL time constant mode: 10 dB 3 sec, 20 dB 7 sec
DC Output	BNC connector in rear. Output -0.1 to -1.0 V for each range simultaneously with meter reading. Output proportional to square of input voltage. Source resistance approximately 1.7 k Ω .
Input Connectors	BNC, convertible to binding posts
Mechanical Specifications	Color: gray panel and case Dimensions (inches): 6.1 H x 7.8 W x 10.2 D Weight: 9.5 pounds Shipping weight: 14 pounds
Optional Accessories	Model 1301 High Voltage 80 db Attenuator Probe for measurements to 10,000 volts at frequencies up to 1 MHz. Input impedance is > 10,000 M Ω shunted by < 4.5 pF. Model 600 Shunt Resistor Assemblies plug into input of Model 323 for measurement of current. Resistor values are in decade steps from 0.01 ohm to 1,000 ohms, thus making it possible to read current from the voltage scales. Model 800 Rack Mounting Kit, for adapting one (or two) Model 323 voltmeters to 7" x 19" rack, without modification of Model 323 (See below)



BALLANTINE LABORATORIES - BOONTON - N. J.

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2-67-Y-3

SENSITIVE **TRUE-RMS** RF MILLIVOLTMETER – MODEL 340

Voltage range: 300 μ V to 3 V

Frequency range: 0.1 Mc to > 1,000 Mc

FEATURES

- **TRUE-RMS VOLTAGE MEASUREMENTS ON A WIDE RANGE OF WAVEFORMS**
- **MAY BE CALIBRATED USING DISTORTED SINUSOIDAL SIGNALS**
- **HIGH, UNIFORM ACCURACY OVER ENTIRE FIVE INCH LOGARITHMIC SCALES**
- **UNIFORMLY HIGH RESOLUTION OF APPROXIMATELY 1% PER MM OF ARC WHETHER AT FULL SCALE OR DOWN SCALE**

GENERAL DESCRIPTION

Model 340 RF Millivoltmeter is a sensitive, wide-band, *true-rms* voltmeter for measurements from 300 microvolts to 3 volts at frequencies from 0.1 Mc to higher than 1000 Mc. Use of two hand-calibrated logarithmic voltage scales, each five inches in length, results in uniform accuracy in % of reading anywhere on either scale. This also results in uniformly high resolution over the entire scale, e. g. 1% of reading per mm of arc whether at full scale or bottom scale. Stability of the voltmeter as a function of line voltage and temperature, together with the unusually high accuracy and resolution, and the independence of the waveform of the signal being measured, make the Model 340 a truly important advance in RF instrumentation.

The true-rms feature of Model 340 is particularly important in that the user may make measurements on either sinusoidal or badly distorted signals, and be assured of a true-rms result. Such results cannot be obtained using a peak or average-responding instrument. Model 340 will produce results that can be specified without regard to purity of signal and can thus be more useful in setting standards for procedures that can be used at other locations. Another advantage is that during calibration procedures, purity of waveform of the signal generator output will not affect the results.

Signal voltages are measured in the Model 340 by a probe which is connected to the voltmeter by 3 feet of



cable. This allows positioning of the probe exactly at the point at which the voltage is to be measured, thus minimizing errors due to transmission line effects.

Accessory units and Adapters are standard equipment and are described under "Specifications" following. These have been designed to (1) facilitate in-circuit measurements, (2) to make measurements on a 50 ohm line, and (3) to connect the voltmeter into a co-axial line of the Type N or BNC variety. A 40 db Attenuator Model 1340 may be used with any of the accessories. It is supplied to insure true-rms measurements from 30 millivolts to 3 volts. An optional HV Attenuator, Model 6340, is available for rms measurements from 3 V to 300 V.

Calibration: Model 340 accuracy is specified and guaranteed from 0.1 Mc to 700 Mc. The instrument may be used qualitatively to frequencies above 1000 Mc.



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"TRUE - RMS ALL THE WAY"

Model 340 measures true-rms voltage regardless of the distortion of the waveform or the magnitude of the applied voltage, hence we say it is "true-rms all the way." Compare this feature with some voltmeters that are true-rms for low voltages, but whose response changes with the magnitude of the voltage, becoming peak-responding at high voltages. This latter characteristic means that the measured voltage is neither true-rms, nor peak except for the limited case of pure sinusoidal signals. Ballantine's Model 340 makes no restrictions on the distortion or

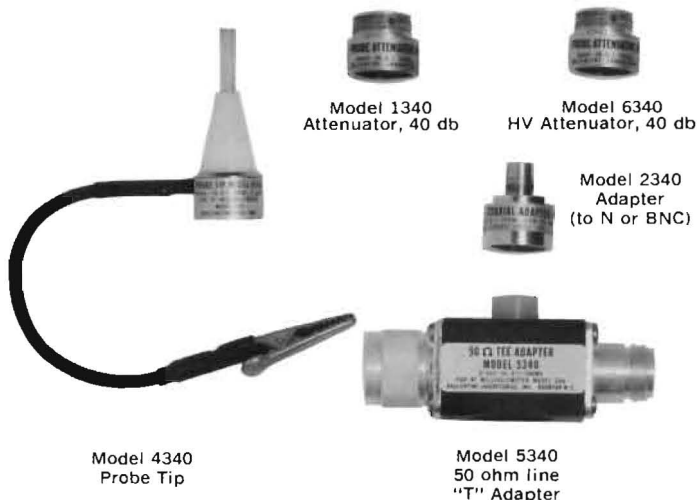
applied voltage, and for this reason it not only *measures* true-rms but it may be *calibrated* using a true-rms device such as the Ballantine Model 440 NBS Micropotentiometer.

Recommended Calibration Standards: The Ballantine Model 440 Micropotentiometers are ideally suited to checking the frequency response and accuracy of the Model 340 RF Millivoltmeter. Ask for brochure. For measuring the frequency response and accuracy up to 30 Mc use the Ballantine Model 393 HF Transfer Voltmeter. Ask for brochure.



Relay Rack Version, Model 340-S/2

(Standard panel color is gray. Quotations will be made for any special panel color.)



Accessories for use with Model 340 in addition to the basic probe and cable

SPECIFICATIONS

Voltage Range—300 microvolts to 3 volts in 8 ranges

Frequency Range—0.1 Mc to > 1,000 Mc, calibrated to 700 Mc

Indication—True-rms on all ranges, all voltages

Accuracy—% of actual reading at any point on the scale.
0.1 Mc to 100 Mc, 4% (This is considerably better than a rating of 2% of f.s.d. for half of the scale)
100 Mc to 700 Mc, 10% (This is considerably better than a rating of 5% of f.s.d. for half of the scale)
700 Mc to > 1000 Mc as a sensitive indicator

Crest Factor—Depends on range. Varies from 100 to 3 over most of the ranges

Scales—Two logarithmic voltage scales, 0.95 to 3.3 and 3.0 to 10.6. One decibel scale, 0 to 10

Input Impedance—30 mV to 3V—> 1 MΩ, 4pF
300μV to 30 mV—25KΩ, 4pF

Mean Square dc Output—0.1 to 1.0 volt dc Internal resistance (for application to 20 kilohms, repeated for each 10 db ac voltage range. This dc output may be obtained simultaneously with voltage measurements.

Input Power—115/230 V, 50-420 cps, 40W

Accessories—For attachment to the probe

Supplied with each instrument

Model 1340 Attenuator, 40 db, for use from 30 mV to 3V

Model 2340 Adapter, for connection to Type BNC or N coaxial connector

Model 4340 Probe Tip, for in-circuit measurements

Model 5340 'T' Adapter, for connection of the vm into a 50 ohm line

Optional

Model 6340 HV Attenuator 40 db for use from 3 to 300V, 100 kc to 100 Mc. Use of this attenuator adds 1% possible error up to 10 Mc and 2% up to 100 Mc

Dimensions (inches)—Portable version, 13 high x 7½ wide x 9½ deep

Rack version, 8½ high x 19 wide x 8½ deep

Weight (pounds)—Portable or Rack, 16

Shipping Weight (pounds)—Portable 22; Rack 34



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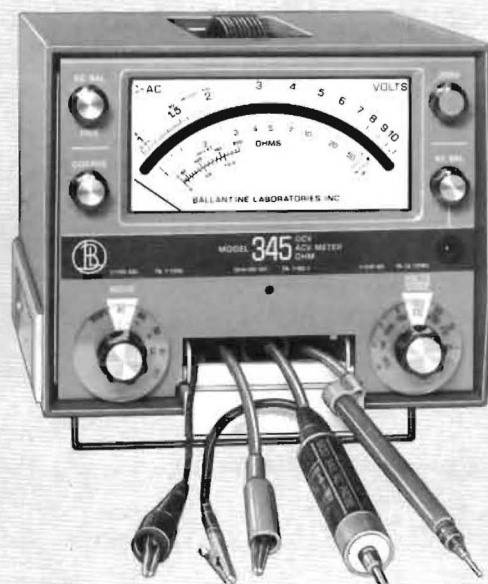
DC/AC VOLTMETER/OHMMETER MODEL 345

0-1100 V DC
1% 1-1100 V

30 mV-350 V AC
2% 1-350 V

0-5000 M Ω
3% 1 Ω -100 M Ω

- LOGARITHMIC INDICATOR
- SINGLE DECADE VOLTAGE SCALE
- AUXILIARY VOLTAGE AND OHMMETER SCALES FOR ZERO READINGS
- INTERNAL CALIBRATION FOR DC AND AC RANGES
- AC PROBE USABLE TO 1000 MHz
- 1/2 RACK MODULAR PACKAGE
- BUILT-IN PROBE STORAGE



Multi-function dc/ac voltmeters, despite their wide usage, have long suffered from two serious drawbacks — a multiplicity of scales and poor accuracy specifications. Now, the new Ballantine Model 345 is available free from both these shortcomings.

The Model 345 features a single, 5 inch, mirror-backed, logarithmic scale and decade range switching for both ac and dc measurements. The single scale and decade switching provides unrivaled measurement ease, speed, accuracy and resolution. With no wrong scales to read, reading errors are greatly reduced. With decade switching, more measurements can be made without the need for range switching. The logarithmic scale permits an accuracy specification of 1% **of indication** for dc and 2% **of indication** for ac. Compare this to instruments offering 2% **of full-scale** for dc and 3% **of full-scale** for ac.

In addition to its use as a dc/ac voltmeter, the new Ballantine Model 345 is also a wide range ohmmeter. Decade switching and a logarithmic scale again provide measurement simplicity and an accuracy of 3% **of indication**.

Auxiliary voltage and ohm scales have been added to the Model 345 for low-level measurements and for applications requiring the observation of signals down to zero. The zero control related to these auxiliary scales can also be used to make dc null measurements of signals with changing polarities.

Another feature of the Model 345 is an internal dc calibrator with zener diode regulation. The cali-

brator provides voltages of 0.1, 1 and 5 volts $\pm 0.2\%$ that can be used to recalibrate the dc voltmeter and ohmmeter sections without the use of external standards. The ac voltmeter section can be calibrated by a balancing operation with an internal regulated supply.

With the introduction of the Model 345, Ballantine Laboratories initiates a new packaging convenience for its customers. This instrument features a 1/2-rack modular size, 7 1/2 inches wide and 6-1/16 inches high. Normally supplied as a portable instrument, the Model 345 can be converted to a rack-mounted instrument in minutes with a Ballantine Model 800 Rack Mounting Kit. This kit consists of a special 19 inch rack panel and all hardware necessary to mount two Ballantine modular instruments side-by-side. Either instrument may be mounted, removed or replaced without removing the panel from its rack. A blank filler panel is supplied in case only one instrument is to be rack-mounted. Instrument chassis is electrically isolated from its case and panel and from the rack mounting to avoid problems caused by circulating ground currents.

A storage drawer for probes has been provided in the Model 345. To avoid unintentional separation of probes and instrument, all probe cables are permanently attached to the instrument. By means of a two-position drawer handle, the storage drawer may be opened, the desired probe removed, and the drawer completely reclosed with only this probe cable visible outside the instrument.



BALLANTINE LABORATORIES - BOONTON - N. J.

SPECIFICATIONS

The abbreviation Hz for cps is being used in this brochure

DC VOLTMETER

RANGE	ACCURACY	SCALE
0-100 mV	±1.5% of Ind. ±1 mV	Aux. Red Scale
0.1-1 V	±1.5% of Ind. ±1 mV	Log. 10% Overlap
1-1000 V (3 Decades)	±1% of Indication	Log. 10% Overlap

DC Probe Input — 112 MΩ in parallel with 1.5 pF
Calibration Voltages — 0.1, 1, 5V, ±0.2%, Zener-stabilized
Common lead isolated from case by 44 MΩ and .01 μF
Max. DC voltage between common and case — ± 500 V

OHMMETER

RANGE	ACCURACY	SCALE
0-1 Ω	±3% f.s.d.	Aux. Red Scale
1 Ω-10 MΩ (7 Decades)	±3% of Ind.	Log. Overlap
10-5000 MΩ	±3% to 100 MΩ	Log. to 100 MΩ

Test voltage is 1 V DC at infinite resistance
Actual voltage can be read on 0.1-1 V scale regardless of Ohms range

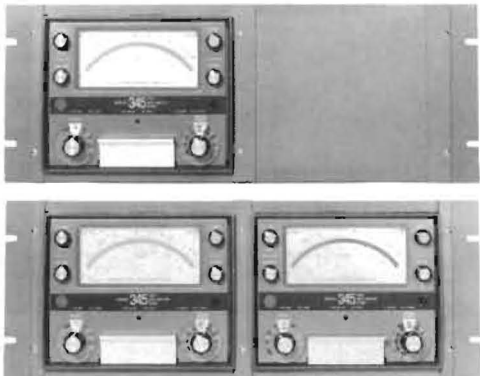
AC VOLTMETER

RANGE	20-50 Hz	50 Hz-100 MHz	100-1000 MHz	SCALE	AC PROBE
0-200 mV	5% of Ind. ±5 mV	2% of Ind. ±5 mV	10% of Ind. ±5 mV	Aux. Red Scale	Input — 10 MΩ and 2.2 pF
0.2-1 V	5% of Ind. ±5 mV	2% of Ind. ±5 mV	10% of Ind. ±5 mV	Log. 10% Overlap	Peak-responding
1-10 V	5% of Ind.	2% of Ind.	10% of Ind.	Log. 10% Overlap	calibrated in
10-100 V*	5% of Ind.	2% of Ind.	10% of Ind.	Log. 10% Overlap	RMS of sinewave
100-350 V*	5% of Ind.	2% of Ind.	10% of Ind.	Log. 10% Overlap	

*Max. RMS Sinewave Voltages — 350 V at 100 MHz, 100 V at 350 MHz, 35 V at 1000 MHz

GENERAL

- TEMPERATURE RANGE** — Operating 15 to 35°C
Storage — 20 to 50°C
- POWER REQUIREMENTS** — 115/230 V ± 10%, 25 W, 50 or 60 Hz, as specified.
- DIMENSIONS (INCHES)** — 1/2 Rack Modular, 7.8 W, 6.1 H, 10.2 D.
Can be rack-mounted with BL Model 800 Rack-Mounting Kit.
No modifications required to mount in HP Modular Enclosures.
- WEIGHT (POUNDS)** — Instrument alone 12.2
Shipping 15
- OPTIONAL ACCESSORIES** — Model 1345 50 Ω Tee adapter. Type N connectors.
— Model 2345 coaxial adapter for type N and BNC connectors.
— Model 3345 DC high-voltage adapter. 10,000 V max.
— Model 800 Rack-Mounting Kit. Mounts 1 or 2 Model 345's in 7 by 19 inch relay rack. Blank filler panel supplied.



Single and dual 19 inch rack panel installations of Model 345



All probes neatly stowed in pull-out drawer



All probe cables neatly wound up in rear



BALLANTINE LABORATORIES - BOONTON - N. J.

PRECISION, TRUE-RMS ELECTRONIC VOLTMETER – MODEL 350

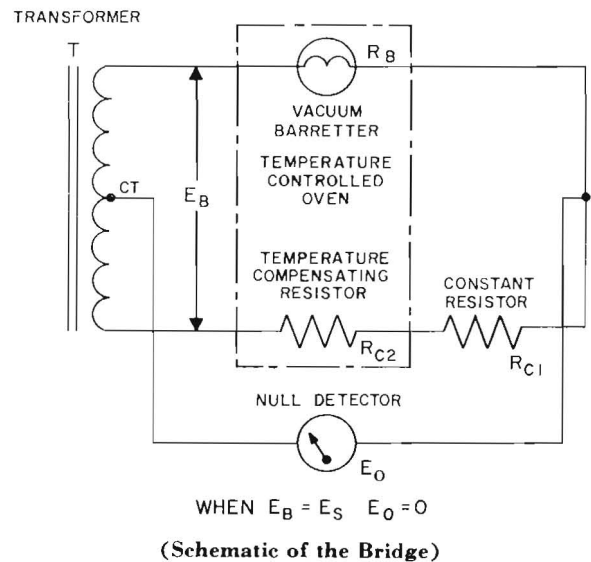
- **MEASURES TRUE-RMS OF WIDE RANGE OF WAVEFORMS**
- **1/4% ACCURACY**
- **DIGITAL READOUT**
- **QUICK READINGS TO ACCURACIES PREVIOUSLY OBTAINABLE ONLY BY SPECIALLY TRAINED PERSONNEL IN WELL-EQUIPPED STANDARDS LABORATORIES**

GENERAL

Measurement of a non-sinusoidal voltage, accurate to 1/4%, can now be made in a few seconds using the Ballantine Model 350 True-RMS Voltmeter. Prior to the availability of this instrument, such a voltage could be measured to this accuracy only by an involved series of steps in which the heating power of the ac was equated to that of dc by means of a thermocouple as intermediary, and then by measuring the dc voltage, with ultimate reference to a dc standard cell. The method was accurate, but required much certificated equipment and a carefully trained technician. Ballantine Laboratories developed the Model 350 to simplify the method and the required training.

PRINCIPLE OF OPERATION

The Model 350 measures the TRUE-RMS of an unknown voltage by attenuating it to a standard level using an attenuator which is calibrated in terms of input voltage. The standard level is indicated by a nonlinear bridge which consists of a center-tapped transformer T and two arms. A constant resistor R_{C1} and a temperature compensating resistor R_{C2} form one arm, a barretter R_B , the other. The barretter resistance depends on the voltage E_B applied to the bridge. At one input voltage E_S , the bridge is balanced and the output voltage E_O is zero. This input level is used as the standard level E_S of the voltmeter. By proper design of the barretter, and using a temperature controlled oven, the standard level stays within a few hundredths of a percent over a wide ambient temperature range for several thousand hours of operation.



BALLANTINE LABORATORIES - BOONTON - N. J.

LONG, RELIABLE LIFE

The Model 350 is designed for reliable operation and long life. High grade components, such as RCA-Red 10,000 hour tubes in amplifier circuits, matched hermetically sealed resistors for measuring circuits, a voltage reference circuit with better than 0.01% stability per 1000 hour operation, and long-life silicon rectifiers in the hv power supply are used. Because of this, a life in excess of 10,000 hours is expected from the instrument, with calibration stability in excess of 1000 operating hours.

CERTIFICATION

Ballantine Laboratories calibrates and certifies Model 350 Voltmeters using standards traceable to the National Bureau of Standards. A certificate to this effect is supplied with each new instrument. Subsequent cali-

bration and certification will be made at the normal price of \$60.00 plus transportation charges. An additional charge is made if repairs are required prior to recalibration.



19 Inch Relay Rack Version—Model 350-S/2

SPECIFICATIONS

Voltage Range—0.1 V to 1199.9 V in four decades, selectable by push-button as follows:

0.1 V - 1.1999 V
1.0 V - 11.999 V
10 V - 119.99 V
100 V - 1199.9 V

Frequency Range—50 cps to 20 kc

Accuracy—in percent of indication— $\frac{1}{4}\%$, 100 cps to 10 kc, 0.1 V to 300 V; $\frac{1}{2}\%$, 50 cps to 20 kc, 0.1 V to 1119.9 V. A tabulated predetermined correction is applied to voltages over 300 to attain the $\frac{1}{2}\%$ accuracy.

Waveform—Sine or complex waveform with max crest factor (ratio of peak to rms amplitude) of 2. This includes square wave, sine wave, distorted waveforms with up to 50% distortion, and pulse trains with max duty cycle of 0.2.

Precision (Reproducibility of readings)—The precision of Model 350 is 5 to 10 times higher than the specified accuracy. This feature makes the instrument usable for observation of small changes, comparison of two voltages, or for use as a precision transfer device.

Input Impedance—2 megohms in parallel with 15 pF to 20 pF in three higher voltage ranges, 45 pF on lowest voltage range.

Effect of Ambient Temperature—Less than $\pm 0.005\%/^{\circ}\text{C}$ from 20°C .

Effect of Line Voltage Change—The sensitivity changes less than 1/10 of specified accuracy for a line voltage change from 115 V ± 10 V (230 V ± 20 V).

Power Supply—115/230 V, 50 to 400 cps, 60 W.

Dimensions (inches)—Portable, 15 H x 8 W x 10 D Rack, $8\frac{3}{4}$ H x 19 W x 9 D.

Weight (pounds)—19. Shipping weight, 24 for portable and 38 for rack.



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BALLANTINE LABORATORIES - BOONTON - N. J.

11-65-Y-02

NEW

HIGH ACCURACY, ECONOMICAL

DC DIGITAL VOLTMETER MODEL 353

- 0 TO ± 1100 V
- ACCURACY $\pm 0.02\%$ $\pm 0.01\%$ F.S.
ON 1 V, 10 V, 100 V, 1000 V
RANGES
- 4 DIGITS WITH OVERRANGING
TO 5 DIGITS
- 10 MEGOHMS INPUT RESISTANCE
- ALL SOLID STATE



GENERAL

The Model 353 is a self-nulling servo voltmeter. It provides the accuracy of multi-knob manual voltmeters, but with increased measuring speed and at a lower cost. Its accuracy is ten-to-one better than conventional electromechanical dvm's.

A NEW APPROACH

With the Model 353, Ballantine offers a new approach to dc voltage measurements. Novel circuits make it possible to produce an economical instrument in a small, light weight package which will meet both production and laboratory needs for precision dc voltage measurements.

Featuring a servo-driven three-digit counter as the basic automatic readout, many virtues of both digital and analog meters are combined. The well lighted in-line numerical readout with illuminated decimal point and range information, provides fast and unconfused readings, while the turning counter wheel follows and permits observation of slowly varying signals. The position of the last digit can be interpolated to the nearest tenth, thus avoiding the typical ± 1 digit restriction of a fully digitized display. A red light indicator warns of exceeded range or wrong polarity.

The accuracy and resolution of this basically three-digit system can be increased tenfold with a novel circuit.* By manually pre-selecting the most significant digit, one full digit can be added to the readout and the resolution increased from .02% at full scale (in normal mode) to .002% (in expand mode). A special holding circuit prevents unnecessary counter wear during the expand switching.

For production use an auxiliary switch, either foot-operated (Model 1355) or activated by other test equipment, can be connected to terminals provided at the rear. This switch can be wired to hold a reading until a new measurement is to be made, or to allow continuous measurements until closed. A manual hold switch is also provided on the front panel.

Surprisingly simple circuitry, sturdy construction, and the all-silicon solid state components add notably to the reliability and the life of the Model 353. Conservative operation of all electrical components further assures long life and outstanding performance. Should maintenance be required, the printed circuit board and all switches are readily accessible.

The Model 353 is packaged in the compact Ballantine 1/2 rack modular case. Although it is normally supplied as a portable instrument, it can be rack mounted in minutes using the Ballantine Model 800 Rack Mounting Kit.

*Patent applied for

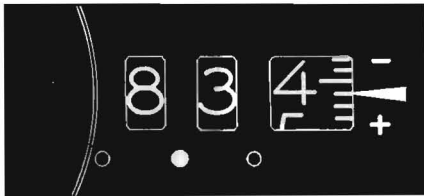


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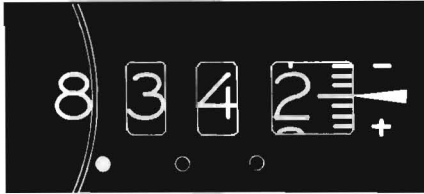
OPERATION

Model 353 is semi-automatic in that it requires two manual operations (1) set mode knob to NORMAL and note first digit of the readout, (2) set mode knob to EXPAND position corresponding to the first digit of the readout in (1). The voltage will then be indicated quickly and automatically to four digits or to five in overrange. One more digit may be obtained by interpolation. Example:

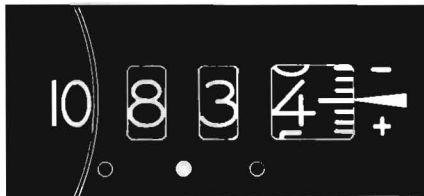
Step 1.
NORMAL
Mode
8.342 V



Step 2.
EXPAND
Mode
8.3420 V



Approaching
Full Scale
presentation
108.340 V



APPLICATIONS

For fast high accuracy laboratory measurements — As a working standard — For high resolution, multi-channel monitoring — For fast and fatigue-free production line tests of dc voltages, using optional Model 1355 Foot Switch — For regulation, accuracy and stability tests on power supplies — For linearity checks on accelerometers, gyros, converters — As a readout device for analog computers — For incoming inspection — For voltage, temperature coefficient and stability checks of zener diodes — For calibration checks of moving coil indicators — For high resolution readout in parallel with the moving coil indicator of analog meters.

SPECIFICATIONS

FS Voltage Ranges	
EXPAND mode	1.1, 11, 110, 1100 V with 0.25% overranging
NORMAL mode	0.1, 1, 10, 100, 1000 V with 2.5% overranging
Accuracy	
EXPAND mode	±0.02% of reading ±0.01% fs
NORMAL mode	±0.2% fs
Resolution	
EXPAND mode	0.002% fs
NORMAL mode	0.02% fs
Input Resistance	
Common-Mode Impedance	
> 200 MΩ < .02 μF	
Common-Mode Rejection	
> 1,000,000:1 for dc and ac not at power line harmonics	
> 10,000:1 at line harmonics	
Maximum Common-Mode Voltage	
600 V peak	
Design	
All solid state	
Display	
4 digits with overrange to 5	
Power Requirements	
115/230 V, 50 to 60 Hz, 16 W	
Size (inches)	
6.1 H x 7.8 W x 10.3 D	
Weight (pounds)	
7.7	
Shipping Weight (pounds)	
12	

OPTIONAL ACCESSORIES

Model 600 Series Resistors are of decade values from 0.01 ohm to 1000 ohms and may be used to measure direct current from 10 μA to 10 A.

Model 710A AC to DC Linear Converter may be used to measure ac voltages from 1 mV to 1000 V, with degraded accuracy.

Model 800 Rack Mounting Kit may be used to mount in 7 x 19 inch rack one or two Model 353's or any paired combination of Ballantine modular instruments. Blank filler panel supplied.

Model 1320 High Voltage Multiplier to measure voltage to 10 kV.

Model 1355 Foot-operated Switch may be used to hold a reading until a new measurement is made, or to allow continuous measurements until closed.



Model 800 Rack Mounting System for Ballantine Modular Instruments



BALLANTINE LABORATORIES - BOONTON - N. J.

Printed in U.S.A.

12-66-Y-8

AC-DC DIGITAL VOLTMETER MODEL 355

- 10 mV FS TO 1000 V FS, AC
(30 Hz to 250 kHz)
- 100 mV FS TO 1000 V FS, DC
- ONE ECONOMICAL PACKAGE
- READING RETENTION
- OVER-RANGE INDICATION
- COAXIAL INPUT CONVERTIBLE
TO BINDING POST
- ISOLATED SIGNAL GROUND
- AC TO DC CONVERTER OUTPUT
- ZENER REFERENCE



DESCRIPTION

Ballantine presents a versatile, economical digital voltmeter built to the standards of accuracy and reliability that have always been associated with Ballantine voltmeters.

AC voltages from below 1 mV to 1000 V can be measured over the audio range and up to 250 kHz, while the most sensitive dc range of 100 mV FS covers measurements normally not possible with general purpose digital voltmeters.

Model 355 features a servo-driven three digit counter with over-ranging, and combines many virtues of both digital and analog voltmeters in one instrument. The well-lighted readout, with illuminated decimal point, mode and range information, allows fast unconfused readings, while the indicator can follow and allow observation of slowly varying signals. The position of the last digit may be interpolated to the nearest tenth, thus avoiding the typical ± 1 digit restriction of a fully digitized display. As a further aid in reducing reading errors, an over-range indicator is provided to warn of excessive input voltage or voltage of the wrong polarity.

For retention of voltage reading, a switch, either foot-operated or operated by other test equipment, can be connected to terminals provided at the rear. This switch can be wired to hold a reading until a new measurement is to be made, or to allow continuous measurements until closed. A three-position

switch on the front panel may be manually operated also to retain readings either momentarily or permanently.

The Model 355 has a coaxial BNC input, and is supplied with a BNC-to-binding post adapter that converts the input to standard 3/4 inch-spaced binding posts. Signal ground can be isolated from case ground. This feature, together with internal double-shielding, allows off-ground and differential measurements with high common mode rejection.

A dc output proportional to the ac input voltage is available for recording purposes simultaneous with the digital readout, and the amplifier section of the instrument can be used separately as a wideband ac amplifier.

Special emphasis has been placed on the reliability and life of the Model 355. A balanced design using both long-life tubes and silicon semiconductors combines the advantages of both devices. Conservative operation of all electrical components further assures long life and performance. All printed circuit boards and chassis are instantly accessible.

The Model 355 is packaged in the new Ballantine 1/2 rack modular case. Normally supplied as a portable instrument, one or two may be panel-mounted in a 19 inch relay rack in minutes using the Ballantine Model 800 Kit. The Model 355 can also be mounted in an HP modular enclosure without modifications.



BALLANTINE LABORATORIES - BOONTON - N. J.

SPECIFICATIONS

Voltage Range	AC	DC	AC-DC Converter
	0 to 1000 V in 6 ranges	0 to 1000 V in 5 ranges	
Full scale, most sensitive range	10 mV	100 mV	Negative voltage proportional to the AC signal
			100 mV to 1.0 V for each decade range
Frequency Range	30 Hz to 250 kHz	DC	Source impedance
			Approx. 10 kΩ
Accuracy in % of Full Scale	1 mV to 1000 V		Accuracy of conversion
	1/4 %, 50 Hz to 10 kHz	1/4 %	1/2 % 10 mV to 250 V, 50 Hz to 10 kHz
AC Indication	Average-responding. Instrument is calibrated in rms of a sine wave.		1 1/4 % 10 mV to 250 V, 30 to 50 Hz
			10 to 250 kHz
Balancing Time, 0 to Full Scale	4 s max	4 s max	250 V to 1000 V, 30 Hz to 250 kHz
Input Impedance	2 MΩ 25 pF except 40 pF on most sensitive range	2 MΩ	Stability
			Line voltage
AC Amplifier			Less than 1 digit change for 10% deviation from 115/230 V
	Voltage gain	60 db max	Power Requirement
Voltage output	1 V to 10 V RMS for each decade range		115/230 V, 50 - 60 Hz, 52 W
			AC Rejection in DC Mode
Source impedance	Approx. 300 Ω		45 db, 60 Hz; 40 db, 120 Hz
Minimum load impedance	15 kΩ		Input Termination
Frequency response	±1 db, 30 Hz to 250 kHz		Unbalanced, 3 terminal
			Isolation from Case
			> 100 MΩ 1000 pF; max allowable voltage, 500 V, Peak
			Common Mode Rejection
			(AC mode, input shorted)
			60 Hz, > 100 db; 100 kHz, > 80 db
			Maximum Ambient Temperature
			50°C
			Overload Copobility
			At least 80 db, but not to exceed 1.3 kV
			Mechanical Specifications
			Color
			Charcoal gray case, light gray panel
			Dimensions (in)
			7.8 W x 6.1 H x 13.2 D
			Weight (lb)
			13
			Shipping weight (lb)
			18

OPTIONAL EQUIPMENT

Foot switch and cable assembly (for reading retention) Model 1355
High voltage probe (for use on ac to 10 kV rms) Model 1301
Shunt resistors, 0.01 ohm to 1000 ohms (for ac and dc current measurements) Model 600
Rack mounting kit (for 19 inch relay rack mounting of one or two instruments) Model 800. See below.



BALLANTINE LABORATORIES - BOONTON - N. J.

SENSITIVE DC VOLT/AMMETER — MODEL 365

Voltage: 1 μ V to 1kV
Accuracy: 1% above 1mV
Current: 1nA to 1A
Accuracy: 2% above 0.1 μ A

FEATURES

- **1% ACCURACY OF INDICATION ABOVE 1 mV**
- **WIDE RANGE OF VOLTAGE/CURRENT**
- **SIMPLE OPERATION—ONE SCALE TO READ, ONE RANGE KNOB**
- **BUILT-IN CALIBRATION STANDARD**
- **SIGNAL-GROUND ISOLATION**
- **OVERLOAD PROTECTION**
- **DC OUTPUT**
- **5 INCH LOGARITHMIC INDICATOR**
- **94 CPS CHOPPER DRIVE**
- **50-420 CPS POWER OPERATION**

GENERAL DESCRIPTION

DC voltages with the extremely wide voltage range of 1 μ V to 1 kV and currents from 1 nA to 1 A can now be displayed on an analog indicator and measured with unmatched accuracy. The Ballantine Model 365 Sensitive DC Volt/Ammeter, with a single logarithmic scale and range selector, will measure voltages above 1 mV with a constant accuracy of 1% of indication. Currents above 0.1 μ A are measured with an accuracy of 2% of indication.

The accuracy of the Model 365 is supported by a high order of stability gained by both ac and dc feedback techniques and conservative operation of all components. For further assurance of accuracy, a simple and reliable internal standard is available to check calibration accuracy and panel controls can correct the calibration, if necessary, in seconds.

Signal-ground isolation allows floating measurements to 500 volts above panel ground, and ac rejection is provided to reduce the effects of common-mode signals.

Special input circuitry protects the instrument against momentary overloads of 1 kV on the most sensitive

voltage range. Sustained overloads of 100 V are possible on this range. Similar protection is provided for current measurements.

Warmup drift has been made negligible for measurements above 1 mV. The instrument is usable a few minutes after being turned on. Even on the most sensitive range the drift after a half hour warmup is less than $\pm 2 \mu$ V per day.

The Model 365 features a chopper driven by an internal supply at 94 c. The instrument is therefore little affected by power line pickup and can be operated on any common power supply frequency 50 c to 420 c.

A dc output is available simultaneous with meter indications. The instrument can be used to drive recorders or as a sensitive, high-gain dc amplifier.



BALLANTINE LABORATORIES - BOONTON - N. J.

SPECIFICATIONS

Voltmeter

Range	Accuracy*	Input Impedance
100 V —1 kV	1%	30 pF 10 MΩ ± 2%
10 V —100 V	1%	30 pF 10 MΩ ± 2%
1 V —10 V	1%	30 pF 10 MΩ ± 2%
100 mV—1 V	1%	30 pF 10 MΩ ± 2%
10 mV —100 mV	1%	35 pF 5 MΩ ± 3%
1 mV —10 mV	1%	35 pF 5 MΩ ± 3%
100 μV—1 mV	3%	35 pF 5 MΩ ± 3%
10 μV —100 μV	5% ±0.5 μV	35 pF 1 MΩ ±10%
1 μV —10 μV	5% ±0.5 μV	35 pF 1 MΩ ±10%

* of indication AT ANY POINT ON SCALE

Warmup Time—Usable after 30 seconds.

Drift after 30 minutes 1 mV —1 kV < 0.25%

1 μV —1 mV < ±2 μV / day

Stability—All specifications maintained over range of 105 V to 125 V. Expected life before tube change or recalibration—2000 hours or 2 years.

Ammeter

Range	Accuracy*	Input Resistance
100 mA—1A	2%	0.1 Ω
10 mA —100 mA	2%	1.0
1 mA —10 mA	2%	10.0
100 μA—1 mA	2%	10.0
10 μA —100 μA	2%	100.0
1 μA —10 μA	2%	1.0 kΩ
100 nA—1 μA	2%	10.0 kΩ
10 nA —100 nA	5% ±0.05 nA	10.0 kΩ
1 nA —10 nA	5% ±0.05 nA	10.0 kΩ

* of indication AT ANY POINT ON SCALE

Overloads—Voltage, 1 kV momentarily on 10 μV range. Current, 10 mA momentarily on 10 nA range.

Input Signal Isolation—Impedance between signal and panel grounds—R = 100 MΩ min, C = 0.1 μF, max potential = 500 V peak.

DC Amplifier

Range	Gain	Output	Accuracy	Linearity	Noise*	Response Time
100 V —1 kV	—60 db	0.1-1 V	±1%	±0.5%	<30 mV	1.2 s
10 V —100 V	—40 db	0.1-1 V	±1%	±0.5%	<3 mV	1.2 s
1 V —10 V	—20 db	0.1-1 V	±1%	±0.5%	<300 μV	1.2 s
100 mV—1 V	0 db	0.1-1 V	±1%	±0.5%	<30 μV	1.2 s
10 mV —100 mV	20 db	0.1-1 V	±1%	±0.5%	<3 μV	1.2 s
1 mV —10 mV	40 db	0.1-1 V	±1%	±0.5%	<0.3 μV	1.2 s
100 μV—1 mV	60 db	0.1-1 V	±3%	±0.5%	<0.3 μV	1.2 s
10 μV —100 μV	80 db	0.1-1 V	±5% ±0.5 μV*	±5.0%	<0.3 μV**	2.0 s
1 μV —10 μV	100 db	0.1-1 V	±5% ±0.5 μV*	±5.0%	<0.3 μV**	2.0 s

* referred to input terminals ** with source resistance <100 kΩ

Scales—Logarithmic voltage scale, 0.9 to 11. One linear db scale, 0 to 20. A mirror is located between the two scales for precise readings.

Drift—less than ±2 μV / day referred to input after 30 minute warmup.

Phase Shift—180° reference input.

Internal Calibration Standard

Type—Gaseous reference tube.

Stability—Better than 0.1% per 1000 hours operation.

Life Expectancy—30,000 hours.

Adjustment—Internal control permits compensation for aging effects.

AC Rejection—1.5 c ≅ 3 db; 60 c ≅ 45 db; 120 c ≅ 60 db.

Output Resistance—≅ 1667 Ω.

Minimum Load Resistance—zero Ω, I max ≅ 600 μA.

Power Requirements

Voltage—105 V—125 V or 210 V—250 V.

Frequency—50 c—420 c.

Power—40 W.

Fuse—115 V—0.4 A Slo-Blo; 230 V—0.2 A Slo-Blo.

Mechanical Specifications

Color—Portable—gray panel, black wrinkle case. Rack—gray, other colors available on request.

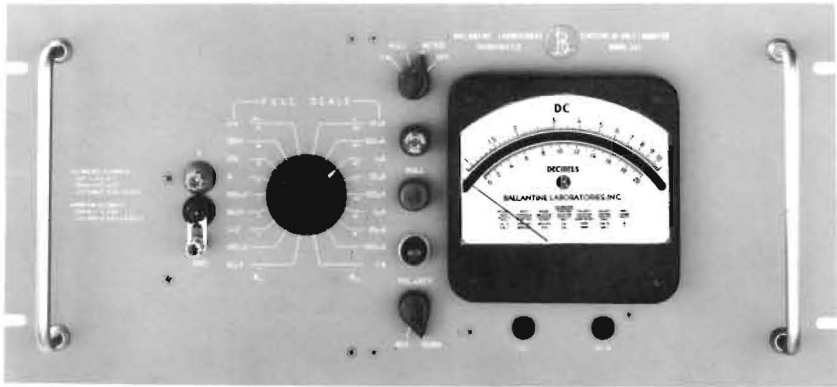
Dimensions (inches)—Portable—13 high, 7½ wide, 10½ deep. Rack—8¾ high, 19 wide, 9½ deep.

Weight (pounds)—Portable or Rack—16 lbs.

Shipping Weight (pounds)—Portable 21, Rack 33.

RELAY RACK VERSION

Model 365-S/2 is the 19 inch relay rack version of Model 365, in the standard gray. Quotations for price and delivery will be made for special panel colors.



Relay Rack Version Model 365-S/2



BALLANTINE LABORATORIES - BOONTON - N. J.

Printed in U.S.A.

11-65-Y-5

**A LABORATORY VOLTAGE STANDARD
FOR 1 MHz TO 1000 MHz**

A - T VOLTMETER MODEL 390

Attenuator-Thermoelement

VOLTAGE RANGE:

10 Volts to 300 Volts at 10 MHz
1 Volt to 300 Volts at 100 MHz
0.5 Volt to 30 Volts at 1000 MHz

FREQUENCY RANGE: 1 MHz to 1000 MHz

ACCURACY: Less than 1% deviation from National Bureau of Standards calibration for period of at least a year.

ACCESSORY: NBS-designed Tee adapter, Ballantine Model 2390, supplied with each Model 390.

APPLICATIONS

The Ballantine Model 390 A-T Voltmeter finds its major use as a laboratory reference standard voltmeter which may be used to calibrate ac voltmeters or signal generators operating in the range of 1 MHz to 1000 MHz. Of course it may also be used as a high level rf voltmeter or monitor with local or remote indication. It has no vacuum tubes and no solid state components, except for a UHF thermocouple. This partly accounts for its excellence as a long-term stable laboratory standard instrument.

Model 390 A-T Voltmeter should be considered complementary to the Ballantine Model 440 Micropotentiometers which are used to calibrate voltmeters and ac voltage sources from 17 microvolts to 1.4 volts at frequencies up to 900 MHz.

Model 390 A-T Voltmeter should also be considered complementary to the Ballantine Model 393 HF Transfer Voltmeter which is used to calibrate voltmeters and ac voltage sources from 1 volt to 200 volts at frequencies up to 30 MHz. The accuracy of Model 393 is better than for Model 390 at corresponding voltages and frequencies but is limited to 30 MHz, or to 50 MHz with special calibration.

DESCRIPTION

Model 390 A-T Voltmeter is based on designs of Myron C. Selby and L. F. Behrent of the National Bureau of Standards. Its manufacture by Ballantine Laboratories is licensed under patents of the U. S. Government.

This instrument consists of an adjustable waveguide-below-cut-off attenuator feeding a UHF vacuum thermocouple. The dc output of the thermocouple is read on an auxiliary microammeter or microvoltmeter. The unknown signal is connected to the input electrode, and the micrometer setting of the



Model 390 A-T Voltmeter may be used to check calibration of an RF Voltmeter or of a signal generator.

attenuator is adjusted to produce a specified output from the thermocouple. The value of the unknown voltage is then obtained from the calibration chart which shows the input voltage for all settings of the micrometer at the frequency of measurement.

Model 390 A-T Voltmeter is designed to reproduce its calibration accuracy to within $\pm 1\%$ for periods of at least a year from the date of its calibration. The stability and long-term reliability of this instrument are the result of the simplicity of its design, the choice of stable, passive circuit elements, and the care taken in the fabrication of its component parts.

The barrel of the variable waveguide-below-cut-off attenuator, for example, is machined from a special casting, then plated and lapped to a final finish. The movable electrode and thermocouple are mounted on a machined carriage that slides inside the attenuator barrel on six nylon pins and two sets of plated finger stocks. The carriage assembly is driven by a two-inch micrometer, calibrated in ten-thousandths of an inch, and coupled to it by means of a spring and ball-bearing arrangement. The thermocouple itself is an insulated type made especially for ultra high-frequency use.

After assembly, each Model 390 A-T Voltmeter is carefully inspected and heat-cycled for one month to remove any mechanical stresses prior to calibration.



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CALIBRATION

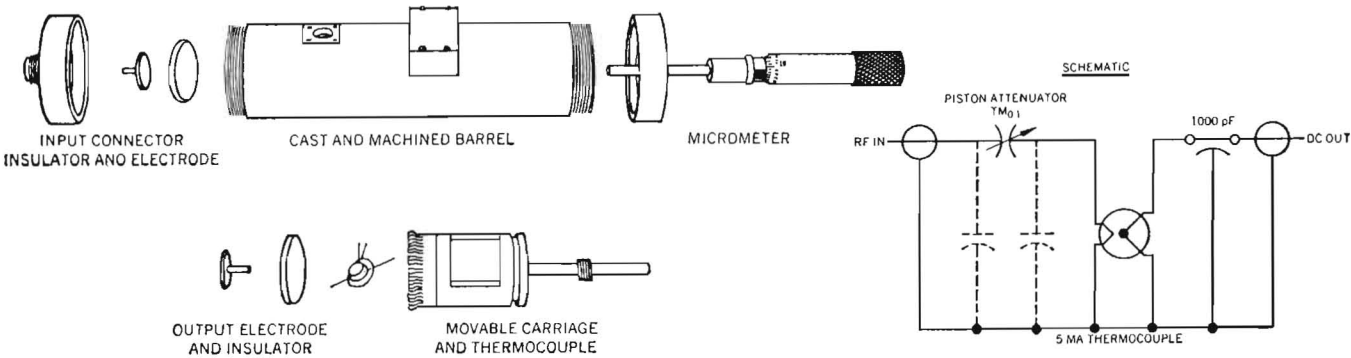
Each Model 390 instrument must be calibrated and certified by the National Bureau of Standards, Boulder, Colorado. NBS will supply a family of data showing frequency, micro- meter setting and voltage. This calibration will be accurate to within $\pm 1\%$ for at least one year.

In order that there shall be minimum error, a 0-200 micro- ampere 5 ohm dc meter, having a mirror-backed scale and as little pivot friction as possible, must be furnished the National Bureau of Standards with the A-T Voltmeter to be

calibrated. A connecting cable is supplied with each instru- ment which should be sent to NBS along with the instrument and microammeter.

If the required dc microammeter is to be provided by Ballan- tine, we will supply the Sensitive Research Model S meter with 1 millivolt full scale, an internal resistance of 5 ohms, and $\frac{1}{2}\%$ accuracy. •

If a customer prefers to have the Model 390 calibrated by NBS in terms of open circuit voltage from the thermocouple, this should be so specified. In this case it will not be necessary to supply the above-mentioned microammeter.



PRICES AND ORDERING INFORMATION

Prices quoted below are net, f.o.b. Boonton, N. J. and are sub- ject to change without notice. They do not include state or local taxes where applicable. Prices do not include charges for calibration and certification by the National Bureau of Stand- ards. Any such calibration charges plus shipping costs will be billed to the customer at Ballantine's cost.

Model 390 A-T Voltmeter,
1 MHz to 1000 MHz complete with
Model 2390 Tee AdopterPrice \$1,925.

Model S Sensitive Research Meter 1 mV,
5 ohms, $\frac{1}{2}\%$ accuracyPrice \$275.

Ballantine cannot quote price and time for colibration by NBS, but an estimate by NBS is approximately \$600 and 4 to 6 weeks for colibration.

Please indicate on purchase order if Ballantine is to arrange for the NBS calibration; otherwise the instrument will be shipped direct to the customer.



Supplied in Mahogany Storage Case as Shown approximately 1/5 Actual Size.



BALLANTINE LABORATORIES - BOONTON - N. J.

CALIBRATION STANDARD

HIGH FREQUENCY TRANSFER VOLTMETER - MODEL 393

- **FOR CALIBRATION OF
AC VOLTMETERS,
OSCILLOSCOPES, OR
SIGNAL GENERATORS,**

**1 VOLT TO 100 VOLTS,
25 CPS TO 30 MC**

- **MAKES USE OF THERMAL
TRANSFER PRINCIPLE
DEVELOPED BY F. L.
HERMACH OF N.B.S. TO
MEASURE AC VOLTAGES
IN TERMS OF
EQUIVALENT DC**

GENERAL

The Ballantine Model 393 HF Transfer Voltmeter with its family of Model 1393 Probes, has been designed for the accurate determination of ac voltages over a wide range of frequencies and waveforms. Because of this ability it is extremely useful for calibration of voltmeters, oscilloscopes, or signal generators.

A set of six Model 1393 Probes is normally supplied with each Model 393 Transfer Unit. Each Probe (See SPECIFICATIONS) may be used over a 2 to 1 range of voltages at any frequency from 25 cps to 30 Mc. Any or all of these Probes may be purchased separately if desired.

The Model 393 Transfer Unit houses the transfer circuit components by means of which it is possible to determine the dc voltage that is equivalent to the rms of the ac being measured. Built-in batteries provide for measurements up to 5 volts. For measurements above 5 volts, an external dc source is required.

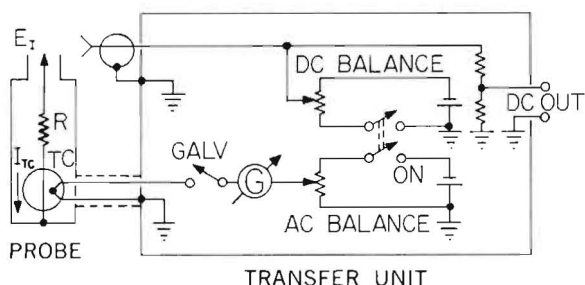


Figure 1—Simplified Circuit Diagram of Model 393 with a Typical Probe.

MEASUREMENT ACCURACY

The overall measurement accuracy depends on the accuracy of the dc voltage measurement and the accuracy of transfer from ac to dc. Modern measuring



Model 393 HF Transfer Voltmeter with typical Model 1393 Probe

equipment easily allows dc measurements to be made to 0.02% accuracy. Extreme care is taken to reduce the transfer error to a minimum. Two main sources of transfer error are:

1. The frequency response error of the transfer impedance of the probe.
2. The dc reversal error in the thermocouple.

The frequency response error of the transfer impedance of the probe depends on the physical dimensions of the components and the probe and is different for probes of different voltage rating. This error remains the same throughout the life of the probe which makes possible the use of a calibration chart to achieve greater accuracy. A typical transfer, *before calibration*, is shown below.

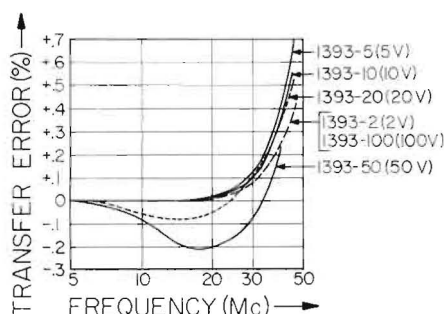


Figure 2—Typical curves showing transfer error as a function of frequency for the six Probes. Note that the maximum error at 30 Mc is well within the Ballantine specification of 0.5% for 10 Mc to 30 Mc, even without applying NBS calibration factor.



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The dc reversal error is caused by the thermocouple. When a typical thermocouple is used to indicate a dc current, the thermocouple output depends on the direction of heater current. For a constant thermocouple output, as much as 0.05% change of the dc heater current may be required when the direction of heater current is reversed. When ac current is compared to the dc current, the result depends on the direction of dc. In either direction the dc does not represent the true equivalent of ac current. The difference is called the "reversal error" which may be reduced substantially by comparing the ac with dc in *both* directions and by taking the average. The Model 393 has provisions to reverse the internal dc source and to eliminate the reversal error.

The ac voltage may be determined most accurately when the dc output is measured with a potentiometer or a precision digital dc voltmeter. For applications where a printed record is required, a printout device may be used with the digital vm.

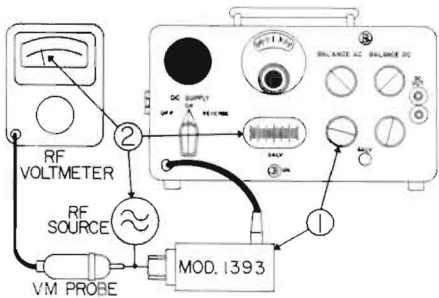


Figure 3—Measuring the frequency response error of an RF Voltmeter is accomplished by changing the frequency of the source while keeping its amplitude constant. The Model 393 is used as the device for determining the standard amplitude as the frequency is changed. The **BALANCE AC** is adjusted once at the desired standard RF level. At all other frequencies the level of RF is adjusted to indicate zero current in the galvanometer.

SPECIFICATIONS

- Voltage Range:** 1 V to 100 V with six probes.
- Frequency Range:** 25 cps to 30 Mc for all probes.
- Accuracy:** 0.1%, 25 cps to 10 Mc; 0.3%, 10 Mc to 30 Mc

The above accuracies may be improved by application of NBS calibration factors, when desired. Ballantine reference standards are traceable to NBS.

Designation, Voltage Range, and DC Input Resistance of Probes:

Model designation	Voltage range	DC input resistance ohms $\pm 5\%$
1393-2	1 V to 2 V	400
1393-5	2 V to 5 V	1000
1393-10	5 V to 10 V	2000
1393-20	10 V to 20 V	4000
1393-50	20 V to 50 V	10000
1393-100	50 V to 100 V	20000

- Thermocouple:**
- Nominal thermocouple current 5 mA.
 - Max. safe thermocouple current 7.5 mA.
 - Nominal dc emf for 5 mA current 7 mV.
 - Nominal couple resistance 8 Ω .

TRANSFER UNIT

- AC Balance Range:**
- Max. thermocouple current 5 mA (7 mV couple output).
 - Min. thermocouple current 2 mA (1.1 mV couple output).
 - Balance indicator—Lightbeam galvanometer.
 - Sensitivity 0.2 $\mu\text{A/mm}$.

- DC Supply built into Transfer Unit:**
- 2 V Range—Source Resistance 2.2 to 2.5 k Ω .
Output Divider 1 to 2, $\pm 0.05\%$.
 - 5 V Range—Source Resistance 0.9 to 1.1 k Ω .
Output Divider 1 to 5, $\pm 0.05\%$.

External supply required for measurements above 5 volts.
Reversal Switch to reverse the polarity of the dc supply provided.

- Internal Batteries:**
- 6 Mallory type RM4RT2 or equal.
 - 1 Eveready type 142 or equal.

Length of Cable to Probe: 24 inches.

ADDITIONAL INFORMATION

- Dimensions of Transfer Unit:** (inches) 12 $\frac{3}{4}$ (W) x 7 $\frac{1}{4}$ (H) x 7 $\frac{3}{4}$ (D).
- Weight:** with six probes, 17 pounds.
Shipping Weight: with six probes, 30 pounds.



BALLANTINE LABORATORIES - BOONTON - N. J.

DC AND AC PRECISION CALIBRATOR — MODEL 420

**Volts: 0-10 V, dc, ac rms, and
ac peak-to-peak**

Frequency of ac: 1 kc

Accuracy: 0.25% to 0.5%

Full specifications below

GENERAL

The Model 420 provides a direct reading accurate signal source for calibrating voltmeters, oscilloscopes and other voltage sensitive devices not only in the laboratory, but also in the shop and in the field where its ruggedness and simplicity will be found advantageous.

The Model 420 is exceptional in having built-in signal sources of both dc and distortion-free ac, and in possessing an *automatic amplitude control system*. The benefits from these factors are that:

(a) An external signal source is not required. The user is not concerned with problems of manual amplitude adjustment, amplitude stability, and uncertainties regarding waveform distortion and hum content.

(b) No monitor meter and associated controls are needed. Human errors in precisely setting a pointer are eliminated, as are any doubts about pivot friction and other meter irregularities which make accuracies better than 1% exceedingly difficult. Furthermore, no fragile components are used so that although its precision is of a laboratory standard, rough and continual handling in shop test set-ups is unlikely to degrade the accuracy.

(c) Only simple setting-up adjustments are necessary. Having previously set one control for the function required, dc, ac-rms or peak-to-peak, the operator merely adjusts the remaining controls to read the voltage to be established. This is immediately available at the output terminals of the Calibrator.

DESCRIPTION

A dual system of highly stable dc and ac voltage sources is incorporated in the Model 420 so as to deliver from zero to 10 volts for three selectable outputs: dc, and rms and peak-to-peak of a 1000 cps pure sine wave.

The ac source consists of an lc oscillator subjected to very close amplitude control by a temperature-compensated barretter bridge both being combined in a highly degenerative loop circuit. This source is applied to the precision decade divider which in turn feeds a unity gain output amplifier incorporating the decimal ratio transformer. Inverse feed-back within the output amplifier is of a very ample order and not only safeguards against normal deterioration of vacuum tubes but also establishes a low internal impedance on even the highest ac output range. Special RCA "Red" tubes and other premium tubes are fitted to enhance the reliability of the instrument and to afford double insurance against deterioration of accuracy following tube replacement.

A combination of a wire-wound decade potential divider and a precision 10-turn potentiometer as an interpolating element furnishes a setting resolution ranging between 1 part in 5000 and 1 part in 50,000



(depending on setting) for output levels from the maximum of 10 volts down to 1 millivolt while below 1 millivolt the resolution is 0.2 microvolt. This high order of resolution is realized for ac outputs by virtue of a further divider comprising an accurately wound output transformer tapped at four successive decimal ratios so as to provide ranges of 0 to 10 millivolts, 10 to 100 millivolts 0.1 to 1 volt and 1 to 10 volts. For dc outputs the decimal dividing transformer is replaced by a second wire-wound potential divider, but by appropriate ganging arrangements the same panel controls serve for both dc and ac (rms and pp) sections which thus cover identical voltage ratios with the same resolution.

A stable voltage for the dc section of the Model 420 is derived from a type of cold cathode tube which is much favored as a voltage reference device. The 5651 tube type used exemplifies the class referred to and has been adopted in the design following a long and exhaustive study of the conditions under which it will operate with the degree of voltage constancy required.

Long-term tests made on the Model 420 indicate that its accuracy will be maintained within the limits specified for at least 3000 hours of continuous or intermittent operation. A calibration certificate is issued with each instrument so that corrections may be applied if desired to realize an accuracy of 0.25% under standard laboratory conditions.



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SOME SPECIAL APPLICATIONS OF THE MODEL 420

Apart from the obvious use of the instrument in calibrating and checking a wide range of voltage devices it can also be readily applied to the accurate measurement of ac and dc potentials and of gain and loss in transmission networks when it is used in conjunction with amplitude detection apparatus in which the required performance characteristics are uniform frequency response and sensitivity rather than precision and calibration stability as are possessed by the Model 420.

Accurate determinations of VHF potentials can be made by using a broad-band diode voltmeter, with known frequency response down to 1000 cps but with otherwise indifferent accuracy, to register a deflection relating to the unknown voltage. Then by following a transfer tech-

nique, which merely involves carefully reproducing the deflection using the Model 420 as an alternate source. the precise value of the voltage is read directly from the dials of the Model 420.

To measure dc potentials accurately all that is required in addition to the Model 420 is a galvanometer or a dc amplifier fitted with an output indicator for use as a null detector. The method is a potentiometric one in which the output of the Model 420 is connected with correct polarity to the unknown source via the null detector and then set to produce zero deflection of the latter. Again the precise value of the voltage is read directly from the settings arrived at on the Model 420.

SPECIFICATIONS—MODEL 420

Available Outputs: dc, ac rms and ac peak-to-peak selectable by function switch — Each of the three outputs covers 0 to 10 volts in four ranges; 0-10 millivolt, 10-100 millivolt, 0.1 to 1 volt and 1 to 10 volt corresponding to divider settings $\div 1000$, $\div 100$, $\div 10$ and $\div 1$ respectively.

Accuracy (without corrections): $\pm 0.5\%$ on all ranges. A small residual output occurs which will affect the accuracy to a slight extent below 1 millivolt. Additional data in this regard is given below. *A calibration chart accompanies each instrument which can be used to $\frac{1}{4}\%$ accuracy.*

Stability: Long-term; accuracy maintained for at least 3,000 hours of continuous or intermittent operation. Short-term drift; less than $\pm 0.05\%$ per hour after warm-up. *Line voltage variation of $\pm 10\%$ will affect accuracy by less than 0.15%.*

Warm-Up Time: 15 minutes. Change less than 0.2% after first 3 minutes.

Dial Setting Resolution: Maximum of 1 part in 50,000 and minimum of 1 part in 5,000 at upper and lower ends, respectively of each above-mentioned voltage range for all outputs above 1 millivolt. Below 1 millivolt the resolution is 0.2 microvolt.

AC Output Characteristics: rms and peak-to-peak:
Frequency: 1000 cps $\pm 1\%$.
Harmonic content: $< 0.25\%$.
Hum content: $< 0.25\%$.
Residual output for 1-10 mV range: $< 1\mu V$ rms.
Ambient temperature influence: $< 0.01\%$ per degree C.

Internal Impedance & Minimum Permissible Load Resistance on ac Outputs:

Voltage Range	Internal Impedance Ohms Approx.	Minimum Load Resistance Ohms
0-10 mV	4	0
10-100 mV	4	0
0.1-1 V	8	100
1-10 V	18	5,000

DC Output Characteristics:
Residual output for 1-10 mV range: < 20 microvolts.
Ambient temperature influence: $< 0.01\%$ per degree C.
Internal resistance — 4000 ohms approx. at maximum dial settings and proportionately less for lower dial settings.

Power Supply: 115/230 volts, 50-420 cps, 35 watts.

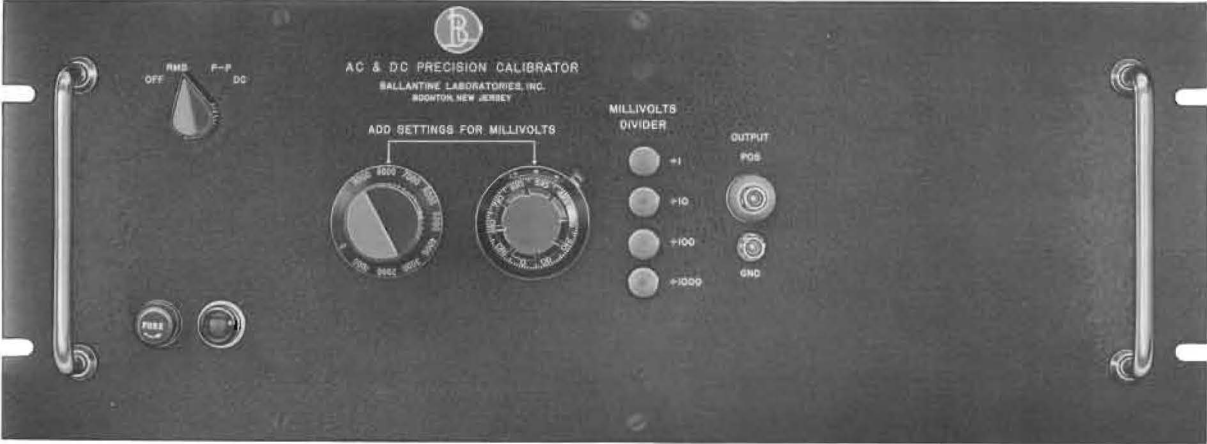
Standard Finish: Panel black crackle, box black wrinkle.

Dimensions: Portable: $10\frac{1}{8}"$ H, $6\frac{3}{4}"$ W, 6" D.
Rack: $6\frac{3}{16}"$ H, 19" W, $5\frac{1}{2}"$ D.

Weight (lbs.): Portable $10\frac{1}{2}$, rack 11.

Shipping Weight (lbs.): 15, rack 26.

The Model 420 Precision Calibrator can also be supplied for relay rack panel mounting. This is known as a Model 420-S/2.



Special Version Model 420-S/2

FEDERAL STOCK NUMBER

Purchased by U. S. Government agencies under Federal Stock Number 6625-555-2217.



BALLANTINE LABORATORIES - BOONTON - N. J.

NEW AC/DC HIGH VOLTAGE

PRECISION CALIBRATOR MODEL 421A

and Optional Error Computer (Model 2421)

- Portable
- 0 - 1110 volts AC
- 0 - 111 volts DC
- RMS or Peak-to-Peak
- 400 Hz or 1000 Hz
- 0.15% accuracy to 111 volts
- Digital readout
- Four digit resolution
- Provision for use with Error Computer for fast meter calibration directly in % error

APPLICATIONS

For accurate calibration of voltmeters, oscilloscopes, recorders, or other dc or ac voltage sensing devices. It may also be used as an accurate, stable source for measurements of gain or loss or as a stable biasing source for bridges or strain gages.

GENERAL DESCRIPTION

Model 421A is a source of ac or dc voltage that can be precisely set to any desired value up to 1110 volts ac or up to 111 volts dc. The selected voltage is indicated digitally to four significant figures on each of six decade ranges. A binding post or UHF coaxial output is provided for all voltages up to 111 V and a specially protected receptacle is provided for voltages from 100 to 1110 V. Up to 111 volts the output may be positive or negative dc, or it may be 400 or 1000 Hz, RMS or Peak-to-Peak. The high voltage output provides any value from 100 to 1110 volts at 400 Hz, RMS or Peak-to-Peak. The specifications below indicate an order of accuracy and stability well within the strictest requirements for calibration of such instruments as analog voltmeters and oscilloscopes.

Both the ac and dc outputs are obtained from a highly stabilized, low-distortion LC oscillator whose amplitude is maintained at a constant level by use of an RMS-sensing barretter bridge housed in a temperature-controlled oven. This device maintains a constant input to the attenuator system over a wide range of power line voltage, ambient temperature, or condition of vacuum tubes. This constant input to the attenuator is then divided by ratio transformers, amplified, and



fed to a decoding output transformer. The design of the circuitry is such that any voltage may be selected between 100 μ V and 1000 V with at least four digit resolution. The dc outputs are achieved by rectifying the regulated ac and using resistive dividers for each range. The combination of these design features insures the specified accuracy over a long reliable life.

NEW FEATURES IN MODEL 421A

Model 421A offers three important new features in addition to those in the Model 421 which it replaces. These are (1) provision for high voltage ac output of 100 V to 1110 V at 400 Hz, RMS or P-P, (2) a lower source impedance on ac, (3) provision for connection of optional Model 2421 Error Computer which speeds up calibration and indicates errors directly in % of reading.

OPTIONAL ACCESSORY MODEL 2421 ERROR COMPUTER

The Model 2421 Error Computer is an optional accessory which when connected to any Model 421A provides for a change in its output up to $\pm 5\%$ as read directly on the dial of Model 2421. The instrument under calibration is fed its nominal voltage by setting the voltage knobs on the Model



BALLANTINE LABORATORIES - BOONTON - N. J.



Model 2421
Error Computer

421A. The dial on the 2421 is then adjusted until the instrument under calibration reads its nominal value, and the % error of the instrument is then read directly from the scale of the 2421. Another feature of the 2421 is that the tracking error of an instrument under calibration can be measured directly in % in the presence of range error.

RACK VERSIONS

Model 421A-S2 is the rack version as shown below. Special panel colors will be supplied at a slightly higher price than the standard Ballantine gray. Model 2421 Error Computer may be connected into a jack on the front of the 421A-S2. Another rack version called 421A-S3 has the 2421 Error Computer permanently mounted on the panel. Purchasers should specify which version is required, and also if a special panel color is required.



Model 421A-S2 (Rack Version)

SPECIFICATIONS

Output modes AC: 400 Hz, RMS or Peak-to-Peak
AC: 1000 Hz, RMS or Peak-to-Peak
DC: Positive or negative

Output voltage at UHF connector
Six decade ranges, 1.11 mV full scale, to 111 V full scale, dc or ac
AC may be 400 or 1000 Hz, RMS or Peak-to-Peak, as selected

Output voltage at high voltage receptacle
100 V to 1110 V ac, 400 Hz, RMS or P-P, as selected

Accuracy of output EMF
At full range
dc and ac modes ±0.1 %
100 - 1110 V, 400 Hz ±0.3 %

Linearity of controls
ac modes ±0.05 % of setting
dc modes* ±0.1 % of setting
*dc ranges are controlled from full range to 1/10 full range, but not below

Residual output (controls at full counterclockwise)
ac ranges, ±0.005 % of full range, ±1 μV
dc ranges, not controlled. Typical value is 0.2 % of full range ±5 μV on coaxial output using Model 1421 Low Thermal EMF connector and cable.

Calibration certificate
A calibration certificate is supplied with each Model 421A

Source Resistance	Range	AC (ohms)	DC (ohms)
	1000 V	±1000*
	100 V	±10*	1000 ±5 %
	10 V	±1*	1000 ±2 %
	1 V	0.6 ±30 %	100 ±2 %
	100 mV	0.4 ±30 %	10 ±2 %
	10 mV	2.2 ±10 %	1.1 ±10 %
	1 mV	2.2 ±10 %	0.22 ±20 %

*Source resistance may be positive or negative by the values shown

Stability
Line voltage effect, 120/240 V ±10 % AC ranges ±0.05 % max
DC ranges ±0.1 % max
Ambient temperature effect, 25°C ±10°C ±0.005 % / °C max
Short time stability (1 hr) ±0.01 %
Recommended calibration period 1000 hrs of operation or 1 year

Waveform
Distortion 0.15 % max
Frequency Nominal, ±2 %
Hum and noise component ±0.05 % of full range max
Ripple (rms) on dc 0.1 % of full range ±50 μV

Warmup Time To 0.05 % of final value in 20 minutes

Power Requirements 115/230 V, 50 - 420 cps, 40 W

Dimensions (inches) Portable 10½ D x 7½ W x 13½ H
Rack 10 D x 19 W x 7 H

Weight (pounds) Portable 20; Rack 21

Shipping Weight (pounds) Portable 27; Rack 36

OPTIONAL ACCESSORIES

Model 1421 Low Thermal EMF Connector and cable, for use on dc below 100 mV.
Model 2421 Error Computer with cable 2 feet long, for use with Model 421A or rack version 421A-S2.



BALLANTINE LABORATORIES - BOONTON - N. J.

Printed in U.S.A.

11-66-Y-5

INSTRUCTIONS

for

MODEL 2421 ERROR COMPUTER

1. General

Model 2421 Error Computer is an accessory to the Ballantine Model 421A Precision Calibrator. When connected to a Model 421A, the Model 421A output can be changed by a known percentage by dialing the change on the scale of the Error Computer. A typical application is in the rapid and direct determination of voltmeter tracking and range errors.

1.1 Specifications

Error Range	$\pm 5.3\%$
Accuracy of Error Setting	$\pm 0.05\% \pm 0.1$ of setting
(in addition to accuracy of 421A)	

2. Operation

Model 2421 may be used with any Model 421A Precision Calibrator. When first connected to Model 421A, the Error Computer should be adjusted as follows:

2.1 Adjustment of Error Computer

2.1.1 Connect a high precision ac voltmeter to the Model 421A. The voltmeter should have repeatability of 0.1% or better and negligible frequency response difference between 0.4 kc and 1 kc. Accuracy of voltmeter is not important. Set Model 421A to 0.4 kc RMS mode and adjust output to any level above 1 V to give a well-repeatable indication on the monitoring voltmeter.

Connect Error Computer to the Model 421A. Rotate plastic dial of Error Computer until the RANGE index indicates 0 (zero). Turn black computer knob counterclockwise until TRACKING error index indicates $\pm 5\%$ on the dial. Observe monitor voltmeter indication carefully and adjust Model 421A output if necessary to achieve an accurately repeatable indication.

2.1.2 Switch Model 421A to 1 kc RMS mode. Without changing any settings observe the monitor voltmeter indication. If it differs more than 0.1% from previous indication, adjust C1 on the rear of Error Computer until 0.4 kc and 1 kc outputs are equal. Repeat steps 2.1.1 and 2.1.2 if necessary.

2.1.3 Set Model 421A to 1 kc RMS mode, disconnect Error Computer and note monitor voltmeter indication. Plug Error Computer into Model 421A, set RANGE error to zero as in 2.1.1 and rotate TRACKING error knob until exactly the same output is observed as without the Error Computer. The



Model 2421 Error Computer

TRACKING error index should indicate within $\pm 0.05\%$ of 0 (zero). If the indication deviates more than $\pm 0.05\%$ from zero, release the set screw of TRACKING error knob and rotate the knob, **without rotating the potentiometer shaft**, until the TRACKING error index indicates zero.

The same procedure may be repeated on dc and 0.4 kc modes. In case of small disagreement of zeros, a setting for the best compromise should be selected.

This procedure calibrates the Model 2421 with a particular Model 421A. No other adjustments are needed as long as the error computer is used with the same Model 421A.

2.2 Use of Model 2421

The Model 2421 has a black error knob marked TRACKING and a clear plastic error dial which can be rotated freely. The plastic dial is marked with two sets of polarity markings; the black outer polarity markings, showing positive error to the right and negative to the left, are associated with the black RANGE index, the white inner markings, showing negative error to the right and positive to the left, are associated with the white TRACKING index.

2.2.1 To change Model 421A output by a known percentage at any mode or setting of Model 421A, connect Error Computer to Model 421A, set error dial so that the RANGE index indicates zero, and set the TRACKING knob to desired percentage deviation, using the outer set of black polarity markings. The Model 421A output is increased with clockwise rotation and decreased with counterclockwise rotation of the knob.

2.2.2 To measure voltmeter error, set Model 421A to the nominal value of the scale point to be measured. Zero the error dial on the RANGE index and rotate the TRACKING knob until an indication exactly on the scale point is achieved. The error may be read from the error dial using the inner white polarity markings.

Example: The voltmeter's indication is brought to the scale mark by turning the computer's knob clockwise to the 2.7 division. The Model 421A output is increased therefore +2.7% or the voltmeter has an error of -2.7% at that scale point.

It should be considered that the error measured with the Error Computer is always the error in percentage of indication. If it is desired to measure the error in percentage of end scale the error should be computed as follows:

$$e_{ES} = e_i \cdot \frac{E_F}{E_{FS}}$$

e_{ES} — error in percentage of end scale

e_i — error in percentage of indication

E_F — test voltage

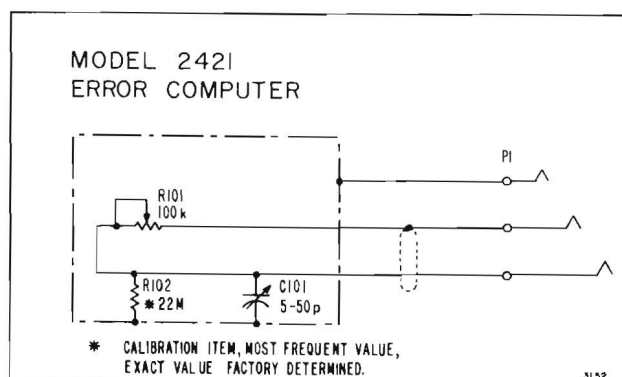
E_{FS} — end scale voltage of the range

Voltmeter error at end scale is called range error. It may be measured for all ranges as described under paragraph 2.2.2. During the calibration of a voltmeter, the measurement of tracking error is often needed. This is the error, at any scale point, reduced by the error at end scale (or range error). The measurement of tracking error is extremely simple when the range error on the measured range is zero. In this case, the error measured at any scale point is the tracking error. However, using the Error Computer, a simple measurement can also be made in the presence of range error.

2.2.3 To measure the tracking error, measure first the range error as described under 2.2.2. Then rotate the error dial so that this range error is indicated under the RANGE index, using the outer set of black polarity markings. The error dial is now zeroed on the TRACKING error index at the end scale error measurement. Now the Model 421A output is standardized with this level as a new reference. To measure the tracking error, set Model 421A OUTPUT VOLTAGE setting to nominal scale point value, rotate the TRACKING error knob until an indication exactly on the scale point is achieved. Read the tracking error from the dial, again using the inner set of white polarity markings.

3. Circuit Description

Model 2421 consists of a 100 k Ω linear variable resistor connected in place of R21, the 50 k Ω resistor used in the Model 421A. A 5.3% voltage drop is normally developed across R21. By replacing it with a 100 k Ω variable resistor, a 0 to 10.6% drop is developed which corresponds to a $\pm 5.3\%$ change in the Model 421A output. A trimmer C1 controls capacitive current through the resistor and equalizes voltage drop at 0.4 kc and 1 kc outputs.



4. Replacement Parts List — Refer to Model 2421 Circuit Diagram

B. L. Part No.	Circuit Symbol	Description	Manufacturer
2447	C101	Capacitor, 5 - 50 pF, Type #503-00 53R	Erie
8203		Knob, mod.	Ballantine
8322	P1	Plug and Cable Assembly	Ballantine
6860	R101	Potentiometer, 100,000 ohms, $\pm 2\%$, Type 975R	General Radio
8320		Range Dial Assembly	Ballantine
1084	R102	Resistor, 22,000,000 ohms, 5%, Type EB	Allen-Bradley

(In some instruments the component listed may not be used at all or its value may differ from the value shown.)

BALLANTINE LABORATORIES, INC.
BOONTON, NEW JERSEY

MICROPOTENTIOMETER - MODEL 440

FEATURES

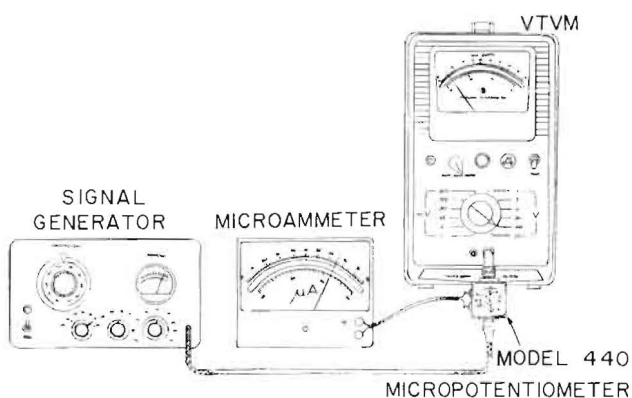
- A simple, robust device for use as a reference or working standard to develop accurately known low voltages at frequencies from 0 to 900 MHz
- A true-rms device, hence not dependent on a particular waveform
- Absolute values easily determined by dc measurements at any time
- The simplest and most accurate method known to
 - a) measure relative frequency response of ac voltmeters and oscilloscopes
 - b) measure absolute accuracy of ac voltmeters and oscilloscopes
 - c) measure absolute accuracy of output of signal generators
- HOW OTHERWISE CAN YOU MEASURE 300 MICROVOLTS at 300 MHz?

DESCRIPTION

The Bollontine Model 440 Micropotentiometer is designed to provide a precisely determined voltage at its output terminal when 0 to 900 megahertz current is fed into the input terminal. The input current flows through a UHF-type thermocouple to a radial resistor of known constant value. The voltage developed across this resistor becomes the standard which is used to calibrate electronic voltmeters, signal generators, oscilloscopes, and other voltage-sensing devices.

The nominal output voltage of a Model 440 is given by the product of the heater current rating of the thermocouple and the resistance of the radial resistor. This voltage can be varied from 1/3 to 1-1/3 of the rated output by varying the thermocouple current over a four to one range.

Radial resistors are available in 21 nominal steps from 0.01 ohm to 22 ohms. Any of these resistors may be plugged into any thermocouple housing assembly having either a 5, 10, 15, 25, or 50 milliamper UHF thermocouple. To cover the complete range of voltages from 17 microvolts to 1.4 volts, see the proposed kit listed on page 2.



Model 440 Micropotentiometer being used to calibrate voltmeter on right.



Model 440 Micropotentiometer. Radial Resistor R is part of the Type N connector on the right. It may be removed and plugged into another housing having a different thermocouple rating than the 5 mA unit shown here.

APPLICATIONS

The Model 440 Micropotentiometer may be used to provide either a **relative** or an **absolute** voltage standard over the frequency range from 0 to 900 megahertz.

As a **relative** voltage standard it is useful in determining the frequency response of instruments such as voltmeters and oscilloscopes in terms of an arbitrary reference level and frequency. As an **absolute** voltage standard it is useful in calibrating devices such as voltmeters, signal generators and oscilloscopes at levels from 17 microvolts to 1.4 volts.

Drawing shows the arrangement for measuring the frequency response of a typical ac voltmeter. The input to the VTVM is held constant by adjusting the output of the signal generator to produce a standard reading on the microammeter at each desired frequency. The VTVM reading is observed for each frequency and results compared to the reading at some reference frequency, say 1000 Hz.



BALLANTINE LABORATORIES - BOONTON - N. J.

VOLTAGE COVERAGE
WITH DIFFERENT RADIAL RESISTOR — THERMOCOUPLE COMBINATIONS

RESISTOR* (OHMS, NOMINAL)	MIN - MAX MICROVOLTS**		
	5 mA THERMOCOUPLE	10 mA THERMOCOUPLE	15 mA THERMOCOUPLE
0.010	17 - 67	33 - 135	50 - 200
0.015	25 - 100	50 - 200	75 - 300
0.022	37 - 145	75 - 290	110 - 440
0.033	55 - 220	110 - 440	165 - 660
0.047	80 - 310	160 - 620	240 - 940
0.068	115 - 450	230 - 900	340 - 1,350
0.10	170 - 670	330 - 1,350	500 - 2,000
0.15	250 - 1,000	500 - 2,000	750 - 3,000
0.22	370 - 1,450	750 - 2,900	1,100 - 4,400
0.33	550 - 2,200	1,100 - 4,400	1,650 - 6,600
0.47	800 - 3,100	1,600 - 6,200	2,400 - 9,400
0.68	1,150 - 4,500	2,300 - 9,000	3,400 - 13,500
1.0	1,700 - 6,700	3,300 - 13,500	5,000 - 20,000
1.5	2,500 - 10,000	5,000 - 20,000	7,500 - 30,000
2.2	3,700 - 14,500	7,500 - 29,000	11,000 - 44,000
3.3	5,500 - 22,000	11,000 - 44,000	16,500 - 66,000
4.7	8,000 - 31,000	16,000 - 62,000	24,000 - 94,000
6.8	11,500 - 45,000	23,000 - 90,000	34,000 - 135,000
10.	17,000 - 67,000	33,000 - 135,000	50,000 - 200,000
15.	25,000 - 100,000	50,000 - 200,000	75,000 - 300,000
22.	37,000 - 145,000	75,000 - 290,000	110,000 - 440,000

*Resistance values are nominal $\pm 20\%$, each marked with its actual value

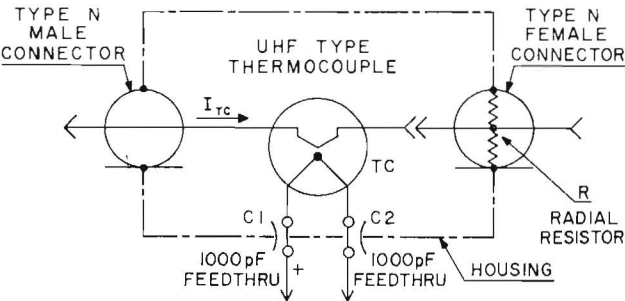
**25 mA or 50 mA thermocouples may be ordered for use with any of the radial resistors shown but normally are used to extend the voltage range to 0.72 or 1.4 volts respectively when using a radial resistor of nominal value 22 ohms.

A COMPLETE KIT

We recommend a kit of radial resistors and thermocouples that will cover the full range of voltages from 17 microvolts to 1.4 volts as follows: 1 ea radial resistors, nominal value 0.01, 0.1, 1.0, 10, 22 ohms, and housings having thermocouples of 5 mA, 15 mA and 50 mA. A selection of resistors from the above table may be made in lieu of any or all of the resistors in the recommended kit. Radial resistors and housings are supplied in a mahogany case. Each resistor is \$175.00 including calibration and certification to 500 MHz, and each housing with thermocouple is \$75.00. Please ask us for delivery information.

CALIBRATION CERTIFICATION

Each Model 440 Micropotentiometer is supplied with a certified Ballantine calibration to 500 MHz included in the price. Calibration from 500 MHz to 900 MHz must be supplied by NBS if required. Tests at Ballantine, based on NBS-calibrated transfer voltmeters, indicate a typical ac to dc difference of less than $\frac{1}{4}\%$ to 10 MHz, less than 1% to 100 MHz, less than 5% to 500 MHz, and less than 15% to 900 MHz. Calibration certification is given with uncertainties of 3% to 5 MHz, 4% to 400 MHz, and 6% to 500 MHz, based on sets of micropotentiometers specially calibrated by NBS for the purpose.



Schematic circuit of Model 440 Micropotentiometer



Model 440 units are supplied in a mahogany case



BALLANTINE LABORATORIES - BOONTON - N. J.

DIRECT READING CAPACITANCE METER — MODEL 520

Range: 0.01 pF to 12 μ F
Test Frequency: 1000 cps
Full specifications below

GENERAL

The Ballantine Model 520 Direct Reading Capacitance Meter represents one of the most convenient means available for measuring capacitors with moderate accuracy over an extremely wide range of values as are encountered in paper, plastic, mica, ceramic and air-dielectric types. Furthermore, the principle of operation permits its use in the measurement of direct capacitance occurring in three-terminal systems, and this property, together with the ability to register capacitance down to one one-hundredth of a picofarad, renders the Model 520 of particular usefulness in segregating stray effects from the measurement of very low value capacitors having appreciable lead to ground capacitance.

The meter indicates capacitance directly to the degree that only one control, the range switch, need be rotated to obtain an on-scale reading which operation requires only a few seconds even if the capacitance being measured is of totally unknown value initially. On the basis of the experience gained by the use of the Model 520 in this Company's laboratories and incoming inspection department it is possible to claim that the instrument will be of considerable utility to any organization concerned with the rapid identification, sorting and testing of a wide range of capacitors.

DESCRIPTION

The Model 520 is an ac operated, self-contained, portable instrument requiring no external oscillator or capacitance standards to meet its specified performance characteristics, as are listed below. In its essentials the Model 520 comprises a grounded 1 kc signal generator having excellent amplitude and frequency constancy, a series of precision current-sensing resistors any of which may be selected by the range switch, a sensitive vacuum tube voltmeter and a means for self-calibration. The circuit is such that the generator feeds the current sensing resistor via the test capacitor both of whose terminals are above ground. The range switching is designed so that the current sensing resistor has negligibly small value in comparison with the reactance of the test capacitor and hence the voltage drop across the resistor is directly proportional to the capacitance value. This voltage drop is detected by the VTVM section of the instrument the meter of which is scaled in a capacitance factor which when multiplied by the range switch setting gives the value of the test capacitor.

It will be seen that any stray capacitance between the test terminals (and any conductors connected thereto) and ground of the instrument fall across the generator



output and across the VTVM input. Provided these secondary loading effects are kept within prescribed limits the strays will not enter into the measurement which thus relates only to the direct capacitance situated between the terminals. Such conditions allow measurements to be made of very small capacitors without ambiguity except for the existence of direct stray capacitance between the leads of such components. To overcome this drawback the test terminals of the Model 520 are arranged in the form of demountable test adaptors one of which has a clip terminal situated in a slotted shield so allowing for almost complete elimination of lead capacitance and residual capacitance between terminals. Two other adaptors are also provided, one for the measurement of bulky capacitors, and the third for permitting measurements at the end of a pair of shielded test leads which do not contribute to the initial capacitance across the test terminals.

Other features of the Model 520 include two additional positions on the range switch that bring into action an internal capacitance standard for checking the meter end points. Panel mounted preset controls permit the correction of any observed deviations as may be necessary at



BALLANTINE LABORATORIES - BOONTON - N. J.

only very infrequent times. The Model 520 is fitted with a large mirror-scale, moving coil meter having a logarithmic grading thus rendering the accuracy independent of the scale position at which any reading is

taken. The meter is furnished further with two concentrically operated adjustable indexes which will prove convenient preset limit indicators when checking capacitance tolerances in incoming inspection departments.

SPECIFICATIONS — MODEL 520

Capacitance Range: 0.01 pF to 12 μ F in nine ranges.

Measuring Potential: 0.01 pF to 0.01 μ F.....10 Vrms.
0.01 μ F to 12 μ F..... 0.1 Vrms.

Measuring Frequency: 1 kc.

Accuracy: $\pm 2\%$ of indication from 0.1 pF to 12 μ F.
 $\pm 5\%$ of indication from 0.01 pF to 0.1 pF.

These limits relate to capacitors having dissipation factors of 0.05 or less. The dissipation factor may be as high as 0.14 before introducing a degradation of 1% in accuracy.

Meter: Logarithmic mirror scale reading from 1 to 12. Two adjustable indexes fitted for presetting capacitor inspection limits.

Power Supply: 115-230 volts, 50-420 cps, 38 watts.

Dimensions: 14" H, 8" W, 8" D, portable construction.

Standard Finish: Panel gray, box black wrinkle.

Weight: 13.5 pounds.

Shipping Weight: 19 pounds.

FEDERAL STOCK NUMBER

Purchased by U. S. Government agencies under Federal Stock Number 6625-797-0242.



BALLANTINE LABORATORIES - BOONTON - N. J.

0.01 ohm to 1000 ohms

PRECISION SHUNT RESISTORS SERIES 600

For measuring alternating currents from
0.1 microampere to 10 amperes when
used with Ballantine AC Voltmeters

GENERAL

Ballantine Electronic Voltmeters can be readily converted into sensitive and accurate direct-reading ac microammeters and ammeters by merely plugging into their input terminals the appropriate Ballantine Precision Shunt Resistor as illustrated in actual size.

In this manner the Shunts may be used to measure currents which are thousands of times smaller than can be measured with thermocouples and rectifier instruments. On the other hand, for the measurement of currents large enough to be registered by thermocouples or rectifier instruments, the resistance introduced by such devices in the circuit being investigated is hundreds of times greater than that arising from the use of the Shunts in combination with a sensitive voltmeter.

DESCRIPTION

All Series 600 Precision Shunt Resistors above 0.1 ohm comprise a $\pm \frac{1}{2}\%$, non-inductive, wire-wound resistor contained in a compact housing which is designed to plug into standard socket posts of $\frac{3}{4}$ " center-to-center spacing and which provides additional similar binding posts for connection to the circuit under test. A similar mechanical arrangement applies to Shunt Resistors of 0.1 ohm and below, but in these cases non-inductively wound resist-



Precision Shunt Resistors	Resistance Ohms	Measurable Current Range					Frequency Range, kc, for max. error from Shunt alone of:	
		Maximum Current	Minimum Current When used with Voltmeter Models:					
			300, 300G 305A* 314A 355 (AC) 710A	300E, 300H 317	302C, 310B, 311, 314A** 320A	316*	1%	5%
601	1	1 A	1 mA	300 μA	100 μA	20 mA	200	500
602	10	300 mA	100 μA	30 μA	10 μA	2 mA	200	1000
603	100	100 mA	10 μA	3 μA	1 μA	200 μA	200	1000
604	1000	30 mA	1 μA	0.3 μA	0.1 μA	20 μA	200	1000
605	0.1	3 A	10 mA	3 mA	1 mA	200 mA	100	400
606	0.01	10 A	100 mA	30 mA	10 mA	2 A	20	50

* For Models 305A and 316 the currents are stated in peak-to-peak values, whereas for all other voltmeters root-mean-square values apply.
** Model 314A used without probe.



BALLANTINE LABORATORIES - BOONTON - N. J.

ance strip is employed and internal connections are made so as to eliminate any indeterminate contact resistances in series with the current sensing portion of the ohmic element which portion is adjusted to an accuracy of $\pm 1/2\%$. All Shunt Resistors are rated at 1 watt continuous dissipation.

True root-mean-square currents may be measured over a range of 0.1 μA to 10 A by using these Shunt Resistors in conjunction with the Model 320A voltmeter, while peak-to-peak current determinations may be made using either the Model 305A or Model 316 voltmeter as a combining instrument.

Power Measurements

Series 600 Resistors may be used as load resistors for power measurements up to 1 watt. The indicated voltage

developed across the resistor must be squared and divided by the resistance to determine average power on average-responding instruments such as Model 310B, or rms power on true-rms responding instruments such as Model 320A.

Example: Use 100 ohm resistor. Measure 10.0 volts.

$$\text{Power is } \frac{E^2}{R} = \frac{100}{100} = 1 \text{ watt.}$$

True-rms power may be *recorded* by connecting a Series 600 Resistor across the input to the Model 320A Voltmeter and a dc recorder to the receptacle labelled "mean square output." The dc is proportional to the average of the square of the input voltage. Output for full scale is 0.2 volt, and source resistance is 1000 ohms. The recorded dc is proportional to rms *power*.

OPERATING CHARACTERISTICS

The upper limit of frequency is controlled by the residual reactances of the Shunt Resistors and by the acceptable error. Thus, for an overall error not exceeding $\pm 1\%$ Models 601 through 604 may be used up to 200 kc, Model 605 up to 100 kc, and Model 606 up to 20 kc. Where larger errors are permissible higher frequencies may be employed as indicated in the table on the opposite side of this sheet.

In a frequency range of 10 cps to 150 kc it is possible to measure currents still smaller than the minimum shown in the table by inserting the Shunts in the input of a Ballantine Model 220C Decade Amplifier, the output of which is connected to a Ballantine Voltmeter. With such an arrangement the minimum measurable current can be computed by dividing the minimum input to the Model 220C, 20 microvolts, by the resistance of the Series 600 Shunt Resistor being used.



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LINEAR, SENSITIVE

AC TO DC CONVERTER MODEL 710A

- NORMALLY USED WITH DC DIGITAL VOLTMETER ON 1 V TO 10 V RANGE
- 1 mV TO 1000 V, 30 Hz TO 250 kHz
- 1/4 % ACCURACY, MIDBAND, TO 250 V
- MOST SENSITIVE INSTRUMENT IN ITS CLASS



Model 710A-S2 (rack version)

GENERAL

The Model 710A AC to DC Converter very accurately converts an ac voltage linearly to a dc voltage which can be measured with a DC Digital Voltmeter, Recorder, or Type K Potentiometer. With such a combination, a wide range of voltages can be measured with better than 0.25% accuracy. This is considerably better than accuracies of present-day vacuum tube voltmeters. Such a system is more sensitive, covers a wider frequency and voltage range, and is much more rugged and foolproof than a laboratory standard instrument of comparable accuracy. It is also adaptable for use by untrained personnel and on production lines.

The instrument covers an input voltage range of 1 mV to 1 kV in six decade ranges. For every decade range the dc output varies linearly from 1 V to 10 V.

The output of the Model 710A Converter is a linear function of the input voltage. The high order of accuracy is shown under SPECIFICATIONS on the next page.

The dc output of the converter is single ended and has a maximum output emf of 10 V with a source impedance of approximately 25 k Ω . The output dc is proportional to the average value of the input waveform for sine waves and distorted waveforms up to 30% total distortion. It is calibrated in terms of the rms of a sine wave.

The model 710A is designed for long and reliable service. Tests on prototypes have indicated over 10,000 hours useful life, which should guarantee several thousand hours of trouble-free and service-free operation.

CIRCUIT DESCRIPTION

The instrument consists of a compensated input attenuator, a four stage feedback amplifier, and an average responding rectifier circuit.

The attenuator unit employs hermetically sealed film type resistors of advanced design. Severe tests at Ballantine Laboratories have indicated that the long-term stability of these resistors approaches that of wirewound units. They have the advantage of being virtually free from reactive components, usually unavoidable with wirewound types. The sealed resistors also have matched temperature coefficients and selected values so that the input attenuator error does not exceed 0.1%. The attenuator is carefully compensated for higher frequencies and has a negligible frequency response error up to 250 kHz.

By operating the tubes below ratings, and applying local as well as overall feedback, the amplifier design results in stable, reliable, long-term operation. The design also permits a wide range of tube replacement with negligible effect on accuracy. The amplifier is followed by a rectifier circuit using hermetically sealed silicon diodes which are virtually free of temperature, humidity, and aging effects. The rectifier circuit is included in the feedback loop.

DIFFERENCES BETWEEN MODEL 710 AND PRESENT MODEL 710A

The most significant difference between the present and the earlier model is *an increase of 10 to 1 in the dc output for each decade of ac input*. This makes it possible to use one additional digit on many dc digital voltmeters so that readings are between 1.0 and 10.0 volts dc instead of 0.1 and 1.0 volt. Another feature that has been added to Model 710A is the possibility of selecting low or high damping. This is particularly useful in reducing ripple on the dc at the lower frequencies. It does not affect accuracy.



BALLANTINE LABORATORIES - BOONTON - N. J.

SPECIFICATIONS

Voltage Range	AC Input	DC Output
	1 mV - 10 mV	1 V - 10 V
	10 mV - 100 mV	1 V - 10 V
	100 mV - 1 V	1 V - 10 V
	1 V - 10 V	1 V - 10 V
	10 V - 100 V	1 V - 10 V
	100 V - 1000 V	1 V - 10 V
Frequency Range	30 Hz to 250 kHz	
Accuracy		
Frequency	1 mV to 250 V	250 V to 1 kV
50 Hz to 10 kHz	0.25%	0.5%
30 Hz to 50 Hz	0.5%	0.75 %
10 kHz to 50 kHz	0.5%	0.75%
50 kHz to 250 kHz	1%	1.25%
Input Impedance (ac)	2 MΩ shunted by 15 pF except 25 pF on 1 mV - 10 mV range	
Output Source		
Impedance (dc)	Approx. 25 kΩ	
Nominal Load		
Impedance (dc)	1 MΩ	
Response	Average-responding Calibrated in rms of a sine wave	
Damping Response		
Time (approx.)	“LO (Low) DAMP”	0.12 seconds
	“HI (High) DAMP”	1.2 seconds
Ripple on dc Output (approx.)		
Frequency	HI DAMP	LO DAMP
1 kHz	0.1%	0.33%
100 Hz	0.48%	3.3%
30 Hz	1.2%	10%
Amplifier Output		
Gain	60 db max.	
Voltage output	1 V to 10 V for each decade range	
Source impedance	300 Ω	
Loading	15 kΩ minimum impedance	
Response	±1 db, 30 Hz to 250 kHz	



Model 710A (portable version)

Stability	Change of line voltage from nominal 115/230 V by 10% changes dc output by 0.17%	
	Warmup time - Usable after 1 minute	
	Drift, DC output < 0.1% after 10 minutes	
	Drift, AC output < 0.5% after 10 minutes	
Power Requirements	115/230 V, 50 - 420 Hz, 35 W	
Dimensions (inches)		
	Portable	6 W, 11 H, 7-¾ D
	Rack	19 W, 7 H, 7-¾ D
Weight (pounds)	Instrument	Shipping Weight
	Portable	10 15
	Rack	15 26
Color	Gray for portable or rack. Special color for rack version at additional cost.	



BALLANTINE LABORATORIES - BOONTON - N. J.

HIGH VOLTAGE AC MULTIPLIERS AND PROBES . . . SERIES 1300

MEASURE VOLTAGES UP TO 10,000 RMS

GENERAL

Any Ballantine ac voltmeter can accurately measure sine wave voltages up to 10,000 volts RMS, or distorted waveforms up to 14,000 volts peak, by adding a Series 1300 Voltage Multiplier at the input.

Multipliers are of two general types—those employing a resistive-capacitive attenuator to reduce the voltage to a level that can be measured by the voltmeter and which multiply the voltmeter indications by 100, and those having a capacitive attenuator which multiply indications by 10,000.

All resistive-capacitive multipliers are plug-in devices that attach directly to the voltmeter panel. Because they will work down to dc, they are usable to the lowest frequency limit of the voltmeter. In most cases their upper frequency limit is also determined by the voltmeter.

The capacitive multipliers are probe-type devices that are connected to the voltmeter by a cable. They feature extremely high input shunt resistance and low shunt capacitance. Their lower frequency limit is 30 cycles for a voltmeter with 2 megohms input and 8 cycles for a 10 megohm input. The upper frequency limit of the Models 1301 and 1311 is 1 megacycle.

All Series 1300 Voltage Multipliers are designed to work with particular Ballantine Voltmeters except for the Model 1301 and 1311 Multipliers. These capacitive attenuators can be used with any instrument having an input resistance greater than 2 megohms and input shunt capacitance of less than 100 picofarads.

The accuracy of each multiplier-voltmeter combination is nominally the same as the voltmeter itself. For the greatest accuracy, each multiplier should be calibrated and adjusted to the voltmeter with which it is to be used. This adjustment will be made without charge if the multiplier and voltmeter are ordered at the same time.

SPECIFICATIONS

Voltage and Frequency Range..... See Tables I and II

HV Input Connector

Models 1301, 1311..... Spring-loaded Probe Tip, Teflon Insulated

All Other Models..... Binding Post, Ceramic Insulated

Output Connector

Model 1311..... Male UHF

All Other Models..... Shielded Banana Plugs, 3/4 Inch Spacing



Typical Series 1300 "Multiplier". This is a resistive-capacitive 40 dB attenuator for measurements up to 10,000 volts ac. Plugs into 3/4 inch spaced binding posts.



Model 1301 HV Probe. This is a capacitive 80 dB attenuator probe for measurements up to 10,000 volts ac. Plugs into 3/4 inch spaced binding posts.



Model 1311 HV Probe. This is a capacitive 80 dB attenuator probe for measurements up to 10,000 volts ac. Plugs into female UHF coaxial connector.



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TABLE I

<i>Voltmeter Model</i>	<i>Multiplier Model</i>	<i>Multiplier Factor</i>	<i>Voltage</i>		<i>Input Impedance</i>		<i>Frequency</i>	
			<i>Max</i>	<i>Min</i>	<i>MΩ</i>	<i>pF</i>	<i>Min</i>	<i>Max</i>
300E	1301	×10,000	10kV	3V	> 10,000	< 4.5	30c	100kc
300G	1301	×10,000	10kV	10V	> 10,000	< 4.5	30c	250kc
300H	1301	×10,000	10kV	3V	> 10,000	< 4.5	30c	1Mc
302C	1310B	×100	10kV	1V	40	3	2c	150kc†
302C	1301	×10,000	10kV	1V	> 10,000	< 4.5	30c	150kc
303	1301	×10,000	10kV	3V	> 10,000	< 4.5	30c	1Mc
305A	1305B	×100	28kV P-P	300V P-P	40	3	5c	500kc†
305A	1301	×10,000	28kV P-P	28V P-P	> 10,000	< 4.5	30c	500kc
310B	1310B	×100	10kV	1V	40	3	10c	6Mc†
310B	1311	×10,000	10kV	1V	> 10,000	< 4.5	30c	1Mc
314A	1310B	×100	10kV	10mV	40	3	10c	6Mc†
314A	1311	×10,000	10kV	1V	> 10,000	< 4.5	30c	1Mc
316	1316	×100	20kV P-P	20V P-P	40	3	.05c	30kc
317	1311	×10,000	10kV	3V	> 10,000	< 4.5	30c	1Mc
320A, 321	1320	×100	10kV	30V	40	3	5c	4Mc†
320A, 321	1311	×10,000	10kV	1V	> 10,000	< 4.5	30c	1Mc
323	1301	×10,000	10kV	3V	> 10,000	< 4.5	30c	1Mc
710A	1301	×10,000	10kV	10V	> 10,000	< 4.5	30c	250kc
355 (ac)	1301	×10,000	10kV	10V	> 10,000	< 4.5	30c	250kc

† Refer to Table II below.

TABLE II — DERATING FOR ALL X100 MULTIPLIERS

FREQUENCY, kc	100	150	300	500	1000	2000	4000	6000
MAX VOLTAGE, kV RMS	10	9	7.5	6.5	5	3.5	2.3	1.8



BALLANTINE LABORATORIES - BOONTON - N. J.

NET PRICE LIST

EFFECTIVE FEBRUARY 15, 1967

Model	Description	Price	Model	Description	Price
220C	DECADE AMPLIFIER	\$160	340	TRUE RMS MILLIVTVM	
220C-S2	Relay Rack Version	\$180		with accessories	\$620
300E	ISOLATED INPUT VTVM	\$290	340-S2	Relay Rack Version	\$640
300E-S2	19 in Relay Rack Version	\$310	345	DC/AC VOLT/OHMMETER	\$395
300E-U2	TWO MODELS 300E's on		350	TRUE RMS DIGITAL VTVM	\$720
	19 inch Panel	\$600	350-S2	Relay Rack Version	\$740
300G	1% ACCURACY VTVM	\$315	353	DC DIGITAL VOLTMETER	\$490
300G-S2	Relay Rack Version	\$335	355	AC-DC DIGITAL VOLTMETER	\$620
300H	ELECTRONIC VOLTMETER	\$260	365	DC VOLT/AMMETER	\$620
300H-S2	Relay Rack Version	\$280	365-S2	Relay Rack Version	\$640
300M	OUTDOORS VOLTMETER	\$430	390	A-T VOLTMETER	
302C	BATTERY OPERATED VTVM	\$310		with Model 2390 Tee (does not	
302C-S2	Relay Rack Version	\$330		include NBS calibration)	\$1,925
303	AC VOLTMETER (Batt/Line)	\$320	393	HF TRANSFER VTVM	
303-01	AC VOLTMETER (Line Only)	\$290		with Six Probes for	
303-50	AC VOLTMETER (Batt/Line)			1 V to 100 V	\$1,270
	with 20 dB Probe	\$382	1393	Probe only, each	\$120
303-51	AC VOLTMETER (Line Only)		420	DC-AC CALIBRATOR	\$395
	with 20 dB Probe	\$352	420-S2	Relay Rack Version	\$415
305A	PEAK READING VOLTMETER	\$460	421A	AC-DC HIGH V CALIBRATOR	\$650
305A-S2	Relay Rack Version	\$480	421A-S2	Relay Rack Version	\$670
310B	VIDEO VOLTMETER	\$310	421A-S3	Relay Rack with	
310B-S2	Relay Rack Version	\$330		ERROR COMPUTER	\$745
314A	WIDEBAND VIDEO VTVM	\$365	440	MICROPOTENTIOMETER	
314A-S2	Relay Rack Version	\$385		Includes One Housing with	
316	LOW FREQUENCY VTVM	\$375		Thermocouple and One Resistor.	
316-S2	Relay Rack Version	\$395		Does not include NBS Calibration	\$250
317	WIDEBAND VOLTMETER			Additional Resistor	\$175
	with Model 2317A Probe	\$495		Additional Housing with	
317-S2	Relay Rack Version	\$515		Thermocouple	\$ 75
320A	TRUE RMS VOLTMETER	\$485	520	CAPACITANCE METER	\$435
320A-S2	Relay Rack Version	\$505	710A	AC TO DC CONVERTER	\$510
321	TRUE RMS/AVER/PEAK VTVM	\$560	710A-S2	Relay Rack Version	\$530
321-S2	Relay Rack Version	\$580			
323	TRUE RMS VM (Batt/Line)	\$520			
323-01	TRUE RMS VM (Line Only)	\$485			

Special paint finishes for rack mounted versions can be supplied to meet customer requirements at an increase in cost of \$20 over the standard S-2 version.

PRICES SUBJECT TO CHANGE WITHOUT NOTICE

ALL PRICES F.O.B. BOONTON, N. J., TERMS NET 30 DAYS

BALLANTINE LABORATORIES, INC.

BOONTON, NEW JERSEY

ACCESSORIES

Series 600	Shunt Resistors—1, 10, 100 or 1,000 ohms	\$20
	Shunt Resistor, 0.1 ohm	\$25
	Shunt Resistor, 0.01 ohm	\$35
Model 617	Terminal Adapter	\$2.50
Model 618	BNC/Binding Post Adapter	\$3.50
Model 800	Rack Mounting Kit	\$35
Model 1300	Multipliers—1300B, 1305B, 1310B, 1314, 1316	\$55
Model 1301	High Voltage Probe	\$62
Model 1311	High Voltage Probe	\$62
Model 1355	Foot Switch & Cable Assembly	\$15
Model 2314	Terminal Adapter	\$15
Model 2317A	Cathode Follower Probe	\$87
Model 3317	60 db Attenuator Adapter	\$37
Model 5314	Probe	\$62
Model 6314	BNC connector for 2317A or 5314	\$20

ACCESSORIES FOR MODEL 340

Model 340	Probe Cable Assembly	\$70*
Model 1340	Attenuator 40 db	\$30**
Model 2340	Adapter, N/BNC	\$ 4
Model 4340	Probe Tip	\$ 8
Model 5340	Adapter, 50 ohm Tee	\$22
Model 6340	40 db Adapter for 3 V to 300 V	\$30

*This should be purchased with Model 1340 as one unit.

**This should be purchased with Model 340 Probe Cable Assembly as one unit.

ACCESSORIES FOR MODEL 345

Pt. #8300	AC Probe and 4 ft. cable assy.	\$60
Pt. #8301	DC Probe and 4 ft. cable assy.	\$14
Pt. #8302	Ohms Probe and 4 ft. cable assy.	\$ 5
Pt. #8303	Common Clip and 4 ft. cable assy.	\$ 2
Model 1345	Adapter, 50 ohm Tee	\$22
Model 2345	Adapter, N/BNC	\$ 4
Model 3345	High Voltage DC Probe	\$35

ACCESSORY FOR MODEL 390

Model 2390	Tee	\$150
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ACCESSORIES FOR MODEL 421A

Model 1421	Low Thermal Connector	\$3.50
Model 2421	Error Computer	\$75

INSTRUCTION BOOKS

(One is supplied free of charge with each instrument)

\$1.50

220C	300	1301-1311
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\$3.50

300D	300E	300G	300H	300M	302C
305	305A	310A	311	311G	314
316	317	320	390	393	420
440	520	700	710	710A	

\$4.50

310B	314A	320A	321	323	340
345	350	353	355	365	421
421A					